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BULLETIN
DE LA
SOCIÉTÉ ENTOMOLOGIQUE D'ÉGYPTE

FONDÉE LE 1er AOÛT 1907

PLACÉE SOUS LE HAUT PATRONAGE DU GOUVERNEMENT ÉGYPTIEN
PAR DÉCRET EN DATE DU 15 MAI 1923

S.O.P.-PRESS
(SOCIÉTÉ ORIENTALE DE PUBLICITÉ)
LE CAIRE - 1957

SOCIÉTÉ ENTOMOLOGIQUE D'ÉGYPTE

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Pour la correspondance administrative et scientifique, échanges de Publications, changement d'adresse et réclamations, s'adresser à Monsieur le Secrétaire Général de la Société Entomologique d'Egypte, Boîte Postale No. 430, Le Caire.

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SOCIÉTÉ ENTOMOLOGIQUE D'ÉGYPTE

CINQUANTIÈME ANNÉE

QUARANTE-ET-UNIÈME VOLUME

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NOTICE NÉCROLOGIQUE

sur le Prof. Hassan Chaker Efflatoun

Notre Société vient d'être cruellement éprouvée par la perte irréparable en la personne du Professeur Hassan Chaker Efflatoun, décédé dans la soirée du 16 Mars 1957.

Membre de la Société Entomologique d'Egypte depuis 1919 et son Vice-Président de 1935 à sa mort, membre correspondant du Museum d'Histoire Naturelle de New-York, Efflatoun faisait aussi partie de l'Institut d'Egypte, de l'Institut du Désert, de l'Académie Egyptienne des Sciences, de la Société Royale d'Entomologie de Londres, de la Société for British Entomology et de l'Association des Biologistes de l'Unesco. Il a représenté l'Egypte à la plupart des Congrès Internationaux d'Entomologie qui se sont tenus à l'Etranger depuis 1928.

Né au Caire, le 24 Novembre 1893, le défunt fait un bref séjour au Collège des Jésuites d'Antoura (Liban) et continue ses études en Suisse et en Angleterre. En 1916, il est admis au Royal Agricultural College de Gloucester et, en 1917, au South Eastern Agricultural College de Wye (Kent), où il décroche ses diplômes avec mention honorable en entomologie.

Issu d'une famille dont la plupart des membres avaient atteint les plus hautes charges de l'Etat, Efflatoun devait en continuer la tradition.

Ainsi, en 1919, dès son retour au Pays natal, il débute comme Conférencier en Biologie à l'Ecole de Médecine de Kasr El-Aini. En 1923, il est transféré au Ministère de l'Agriculture en qualité de Sous-Directeur et, plus tard, de Directeur de la Section d'Entomologie. En 1928, il est nommé Professeur-adjoint de Zoologie à la Faculté des Sciences de l'Université du Caire et de 1930 jusqu'en 1953, époque à laquelle il prend sa retraite, il y occupe la chaire d'Entomologie.

Durant son séjour à cette Faculté, il est élu Vice-Doyen de 1936 à 1950 et, depuis, Doyen jusqu'en 1953.

Tout comme au cours de ses précédentes fonctions, Efflatoun fit toujours preuve d'un sens remarquable d'organisateur, d'une énergie et d'une tenacité incessantes, qui lui permirent d'élever au plus haut niveau de perfection les divers départements qu'il avait eu à administrer durant sa longue carrière, et dont l'exemple le plus remarquable est celui du Département d'Entomologie de la Faculté des Sciences, que l'on peut considérer comme un des mieux équipés qui soit au monde. C'est là et par lui, premier entomologiste égyptien diplômé, que fut formée toute une phalange de brillants entomologistes dont l'Egypte peut s'enorgueillir à juste titre.

Les insectes nuisibles aux plantes, aux animaux et à l'homme, et ceux qui vivent à leurs dépens et qui sont ainsi d'utiles auxiliaires à l'agriculteur, font partie intégrante des cours d'agriculture. Cependant, il existe dans la Nature une infinité d'autres insectes qu'il est indispensable de connaître afin d'établir les affinités morphologiques et biologiques qui distinguent leurs différents ordres, groupes et espèces. EFFLATOUN en avait saisi toute l'importance et en entreprit l'étude. A cet effet, il constitua, durant son séjour universitaire en Angleterre, une splendide collection de Lépidoptères et de Coléoptères anglais. Ce précieux matériel, composé de 7292 spécimens contenus dans 41 boîtes, constitua, en 1928, le premier don du Professeur EFFLATOUN à la Société Entomologique d'Egypte, don suivi par beaucoup d'autres qui vinrent enrichir la Bibliothèque de cette Société.

Le ver du coton, toute la cohorte des prédateurs agricoles, les taons et autres parasites du bétail, la malaria, la peste, le typhus, la typhoïde, l'ophthalmie, l'anthrax, et tant d'autres maladies qui affligent l'humanité, n'ont-ils pas pour origine l'insecte ! Mais que de difficultés l'entomologiste n'a-t-il pas à affronter dans l'étude de ces problèmes d'importance vitale.

Constituer une bibliothèque spécialisée, parcourir sans répit les campagnes de toutes les Provinces égyptiennes, la steppe maréotique, explorer les déserts égyptiens et ses oasis, le Gabel Elba à l'extrême sud-est du Pays, le littoral de la mer Rouge, le Sinaï, camper sous les étoiles ou sous la tente, en toutes saisons, par tous les temps, et souvent au péril de la vie, tout cela fut vecu par EFFLATOUN.

Durant ces expéditions innombrables, il recueillit le matériel indispensable à ses études. Il découvrit une infinité de spécimens qui portent son nom, et d'autres, aussi nombreux, nouveaux pour la science, indépendamment de toute une série d'espèces connues mais qui n'avaient pas encore été trouvées sur le territoire égyptien.

En Egypte, EFFLATOUN se spécialisa dans l'étude des Diptères. Il ne se faisait aucune illusion sur les difficultés que présentait l'étude de cet Ordre des Arthropodes si peu connu, et pourtant si plein d'intérêt. Il est superflu de décrire ici avec quelle maîtrise il en traita les différentes familles, ses travaux étant universellement connus. Le nom EFFLATOUN est entré dans l'histoire de l'entomologie et plus particulièrement dans celle de la diptérologie.

Sa collection de Diptères égyptiens est unique au monde, tant par la richesse du matériel accumulé que par sa préparation incomparable. Respectant les dernières volontés du défunt, ses héritiers ont fait don de cette collection à la Société Entomologique d'Egypte où elle est désormais conservée.

Le désert convenait admirablement au tempérament du Prof. EFFLATOUN, et il s'y réfugiait chaque fois que ses occupations le lui permettaient. La féerie éblouissante des lumières le conquit d'abord; c'était du fantasmagorique jamais imaginé, c'était l'explication évidente de l'existence des adorateurs du soleil; c'était l'aspect et c'étaient les dimensions mêmes des choses qui changeaient, en perpétuel mouvement; c'étaient les distances qui croissaient ou se rapprochaient à vue d'oeil; c'était l'horizon qui s'ouvrait, s'éloignait ou se resserrait, avec la constance uniforme et

Professeur HASSAN CHAKER EFFLATOUN
1893 - 1957

rapide du déplacement de l'angle de réfraction des rayons; c'était la couleur de chaque pierre et de chaque grain de sable qui prenait toutes les teintes, des plus vives aux plus estompées, au passage du moindre nuage, et parfois au moindre mouvement d'air que la chaleur du soleil provoquait.

Puis, petit à petit, lorsque l'oeil avait fini par s'habituer au merveilleux, ce fut son oreille d'artiste qui commença à s'émerveiller à toute la gamme inépuisable des sons qui remplissent les espaces du désert d'un concert miraculeux, à chaque souffle du vent, à chaque vol d'oiseau, au moindre mouvement de l'atmosphère, à chaque pas que l'on fait, à chaque bruit même très très lointain.

Plus il croyait s'être définitivement familiarisé avec tous les secrets et les mystères du désert, et d'en avoir compris toutes les beautés et toutes les richesses, et plus il y découvrait du nouveau qui aiguisait toujours davantage son intérêt, sa curiosité et son admiration.

Il trouvait parfois des cavernes creusées dans la montagne et dans lesquelles ou à proximité desquelles il recueillait des diptères spéciaux, tel le *Vermilio vermilio* du groupe des Rhagionidae, et d'autres spécimens entomologiques d'une biologie étrange, tels les Némoptérides.

Il trouvait aussi d'innombrables vestiges siliceux qui attestaient l'existence de l'Océan sur le désert des milliers de siècles auparavant. Il s'attardait à admirer sur les rivages du golfe de Suez et de la Mer Rouge, ces radiolaires à carapace délicate et d'une finesse insoupçonnable, ces coraux blancs de neige semblables à des plantes, éxecutés par des artistes célestes à la conception surhumaine, et dont la perfection, la richesse et l'existence même en ces lieux forcent à la méditation sur les merveilles de l'Univers, les cataclysmes qui le bouleversent, sur l'infinie faiblesse de l'homme devant les forces cosmiques, sur sa vie éphemère, sur la vanité de ses plans orgueilleux.

Et les délicieuses nuits du désert égyptien qui viennent subrepticement vous surprendre à peine le soleil, en se couchant, aura lancé comme une fusée d'allégresse son augural rayon vert !

C'est tout ceci, et beaucoup plus encore, que le désert lui racontait chaque fois, des journées et des nuits durant, inlassablement, comme une poésie délicate et sublime, comme une merveilleuse symphonie.

Artiste dans l'âme, il a enregistré sur le film la plupart des sites splendides qu'il a rencontrés, les tribus bédouines et leur folklore, les animaux désertiques et les poissons de la Mer Rouge, et ces photos constituent une documentation encyclopédique des plus précieuses.

Il avait la passion des fleurs, aimait les animaux, ne pouvait voir souffrir autour de lui, aidait les misères humaines avec spontanéité, générosité et surtout avec discrétion.

Outre les soucis de sa profession, il avait encore à s'occuper de ses terres. Ses profondes connaissances agricoles et son bon sens le firent rompre avec les méthodes désuètes du passé. Il transforma ses domaines de fond en comble, tant par le choix des cultures que de leur rendement.

L'entourage d'EFFLATOUN était composé d'hommes de science et d'amis éprouvés, et ses après-midi du Dimanche sont restés proverbiaux.

La grande faucheuse a inopinément surpris le Professeur EFFLATOUN alors qu'il rédigeait la deuxième partie de la Monographie des Bombylides de l'Egypte. Cette œuvre posthume, heureusement presque achevée, sera publiée par les soins de notre Société

En sa mémoire, une plaque commémorative portant l'inscription de "Laboratoire Efflatoun" a été apposée sur la porte du laboratoire de la Société dans lequel li a travaillé pendant trois années consécutives.

Nous avons tous pu apprécier les rares qualités de cœur et d'esprit de cet éminent et regretté collègue. Sa mort est un deuil pour les entomologistes de tous Pays.

Liste des travaux publiés par le Prof. H. C. Efflatoun

1920: The life-history of *Telmatoscopus meridionalis* Eaton (Diptera).
1921: Note on the aquatic caterpillar of *Nymphula* sp. (Microlepidoptera).
1922: A Monograh of Egyptian Diptera (I, Syrphidae).
1924: A Monograph of Egyptian Diptera (II, Trypaneidae).
1924: A new species of *Nemestrina* from Egypt (Diptera).
1925: Descriptions of the larvae and pupae of *Schistopterum moebuisi* Beck. and *Terellia planiscutellata* Beck. (Diptera).
1925: Contribution to the knowledge of the Syrphidae of Egypt (Diptera).
1926: A new species of *Cerdistus* from Egypt (Diptera).
1926: Further notes on Egyptian Syrphidae with description of a new species (Diptera).
1927: On the morphology of some Egyptian Trypaneid larvae, with descriptions of some hitherto unknown forms (Diptera).
1928: Le développement de la science entomologique en Egypte.
1929: New species of *Promachus* from Egypt (Diptera).
1930: A Monograph of Egyptian Diptera (III, Tabanidae).
1934: A Monograph of Egyptian Diptera (IV, Asilidae, 1).
1937: A Monograph of Egyptian Diptera (V, Asilidae, 2).
1945: A Monograph of Egyptian Diptera (VI, Bombylidae, 1).

Liste des genres, sous-genres, espèces, sous-espèces et variétés décrits par le Professeur Efflatoun, et de ceux qui lui ont été dédiés

(les noms en italiques désignent les descriptions)

Coleoptera

Cleonus (Pachycerus) *efflatouni* Tewfik, Hospitopterus *efflatouni* Pic.

Diptera

Acanthogeron *auripilus* Efflatoun, Acanthogeron *blanchei* Efflatoun, Acanthogeron *grandis* Efflatoun, Acanthogeron *perniveus* Bezzi, Acrochordomerus *engeli* Efflatoun, Actorthia *efflatouni* Kroeber, Actorthia *pulchella* Kroeber, *Africasia oestroidea* Rohdendorf, Aldrichomyza *longirostris* Hendel, Alloprosopa *efflatouni* Villeneuve, Alloxytropus *anomalus* Bezzi, Alloxytropus *bezzii* Parent, Amictus *aegyptiacus* Parent, Amictus *gebeli* Efflatoun, Amictus *shafiki* Efflatoun, Amphiobetus *gederati* Efflatoun, Anastoechus *aurifrons* Efflatoun, Ancylorrhynchus *elbaiensis* Efflatoun, Anisopogon *parvum* Efflatoun, Anisopogon *pulchrum* Efflatoun, Aphoebantus *dichromatopus* Bezzi, Aphoebantus *efflatouni* Bezzi, Aphoebantus *wadensis* Bezzi, Aphrosylus *parcearmatus* Parent, Apodacra (Xeromyia) *aegyptiaca* Rohdendorf, Apodacra (Xeromyia) *dasystigma* Rohdendorf, Apodacra (Xeromyia) *stenorhina* Rohdendorf, Argyromoeba *bisniphas* Bezzi, Argyromoeba *chionanthrax* Bezzi, Argyromoeba *melanista* Bezzi, Asyndetus *albifacies* Parent, Asyndetus *albifrons* Parent, Asyndetus *chaetifemoratus* Parent, Asyndetus *dubius* Parent, Athyroglossa (Ochtheroidea) *argyrata* Hendel.

Bombylius *bedouinus* Efflatoun, Bombylius *catheriniensis* Efflatoun, Bombylius *minusculus* Efflatoun, Bombylius *moussayensis* Efflatoun, Bombylius *wadensis* Efflatoun.

Caenoneura *robusta* Kroeber, Ceratitis (Trirhithromyia) *efflatouni* Hendel, Cerdistus (Epitriptus) *pallidus* Efflatoun, Cestonionerva *proxima* Villeneuve, Chiasmella sabulonis *rubicunda* Bezzi, Chiromyia *robusta* Hendel, Chiromyia *vittata* Hendel, Chrysozona *siwayensis* Kroeber, Conophorus *aegyptiacus* Bezzi, Crocidium *aegyptium* Bezzi, Crocidium *nudum* Efflatoun, Cyrtosia *abragi* Efflatoun, Cyrtosia *gulperii* Efflatoun, Cyrtosia *injii* Efflatoun, Cyrtosia *luteiventris* Bezzi, Cyrtosia *separata* Efflatoun, Cyrtosia *tetragramma* Bezzi, Cytherea *wadensis* Efflatoun.

Dacus longistylus *clarus* Efflatoun, Dichistus *sinaiticus* Efflatoun, Dichistus *trigonus* Bezzi.

Efflatounanus Philip, *Efflatounia aegyptiaca* Bezzi, *Efflatouniella aegyptiaca* Kroeber, *Efflatounomyia albidopilosa* Rohdendorf, *Efflatounomyia pardalina* Rohdendorf, Empididеicus *efflatouni* Engel, Empididеicus *mariouti* Efflatoun, Empidieicus *nubilis* Bezzi, Epitriptus *desertorum* Efflatoun, Epitriptus *heleni* Efflatoun, Enaresta *iphionae* Efflatoun, Eulalia *oasina* Lindner, Eumerus *cistanchei* Efflatoun, Euscelidia *hishariensis* Efflatoun, Eutropha *ruficornis* Hendel, Exoprosopa (Pterobates) *chrysogaster* Bezzi, Exoprosopa *efflatouni* Bezzi, Exorista *signifera* Villeneuve.

Geron *garagniae* Efflatoun, Geron *intonsus* Bezzi, Geron gibbosus *erythropus* Bezzi, Geron *longibarbus* Efflatoun, Geron *longiventris* Efflatoun, Glossista *albolineata* Bezzi, Glossista *mitidapex* Bezzi, Glossista *thyridophora* Bezzi.

Habropogon *aegyptius* Efflatoun, Habropogon *elegantulus* Efflatoun, *Halaiba cavicola* Parent, Hercostomus *discriminatus* Parent, Heterotropus *aegyptiacus* Paramonov, Heterotropus *bisglaucus* Bezzi, Heterotropus *maculiventris* Bezzi, Heterotropus *magnirostris* Bezzi, Heterotropus *stigmaticus* Bezzi, Heterotropus

xanthothorax Efflatoun, Hirtea *efflatouni* Lindner, Hoplocephala (Hoplocephalonea) *nitigena* Villeneuve, Hydrophorus *nilicola* Parent, Hydrophorus *rufinasutus* Parent, Hygroceleuthus *efflatouni* Parent.

Laphystia *aegyptiaca* Efflatoun, *Leylaiya mimnermia* Efflatoun, Legnotomyia *leyladea* Efflatoun, Leptogaster *elbaiensis* Efflatoun, Leptogaster *faragi* Efflatoun, Leptogaster *longitibialis* Efflatoun.

Machimus *meridionalis* Efflatoun, Mariobezzia *catherinae* Efflatoun, Medetera *araneipes* Parent, Medetera *media* Parent, Metasphenisca *angulicornis* Hendel, Microstylum *nigrosetosum* Efflatoun, Milichiella *argentiventris* Hendel, Miltogramma (Achaetocephalon) *nudum* Rohdendorf, Miltogramma *albifacies* Villeneuve, Miltogramma (*Capnopteron* Rohdendorf), Miltogramma (Miltogrammidium) *fflatouni* Rohdendorf, Miltogrammoides *efflatouniana* Rohdendorf.

Nanoplagia *petiolata* Villeneuve, Nemestrina *jullieni* Efflatoun, Nemotelus brachystomus *aegyptiacus* Lindner, *Neolophonotus* Engel, Neomochtherus *sinaiticus* Efflatoun.

Ochrops *aegyptiaca* Kroeber, Oligochaetus *albescens* Parent, Oligochaetus *albisetosus* Parent, Oligopogon *nitidus* Efflatoun, Ommatus *aegyptius* Efflatoun, Omphrale *fraterna* Kroeber, Orthaetia *micans* Kroeber.

Paractenota *efflatouni* Engel, Petrorossia *latifrons* Bezzi, Petrorossia letho *liliputiana* Bezzi, Phlebosotera *lacteipennis* Hendel, Phlebosotera *striata* Hendel, Phthiria *salmayensis* Efflatoun, Phthiria *tricolor* Bezzi, Phthiria *unicolor* Bezzi, Phthiria *xanthaspis* Bezzi, Phycus *bicinctus* Kroeber, Physocephala *obscureifacies* Kroeber, Pipunculopsis *bivittata* Bezzi, Promachus *aegyptiacus* Efflatoun, Promachus *argentipennis* Efflatoun, Promachus *sinaiticus* Efflatoun, Promachus *tewfiki* Efflatoun, Prorachthes *longirostris* Bezzi, P*rothaplocnemus anthracina* Bezzi, Pseudodorus *nigricollis* Efflatoun (femelle), Pseudomphrale *flavoscutellata* Kroeber, Psiatholasius *fascipennis* Bezzi, Psilopa *pectinata* Hendel, Psilopa *nigricornis* Hendel, Psychoda *aberrans* Tonnoir, Psychoda *efflatouni* Tonnoir.

Rhadinus *khargaiensis* Efflatoun, Rhadinus *tewfiki* Efflatoun, Rhynchospsilopa *nitidissima* Hendel, Rivellia *marginalis* Hendel, Rueppellia *apicalis* Kroeber, Rueppellia *pallida* Kroeber, Rueppellia *robusta* Kroeber.

Sarcophaga *pharaonis* Rohdendorf, Saropogon *elbaiensis* Efflatoun, Sciopus *vicinus* Parent, Setulia *immunita* Villeneuve, Spheniscomyia *aegyptiaca* Efflatoun, Spheniscomyia *debskii* Efflatoun, Spongostydum *antiopa* Bezzi, *Stephanotrypeta brevicostata* Hendel, Stenopogon *elongatissimus* Efflatoun, Stichopogon *flaviventris* Efflatoun, Stichopogon *marinus* Efflatoun, Stomylomyia europea *aegyptiaca* Bezzi, Stomylomyia europea *nigrirostris* Bezzi, Stomylomyia *pusilla* Bezzi, Stratiomyia segnis *deserticola* Lindner, Syllegomydas *efflatouni* Bezzi, Syllegomydas *spinipes* Bezzi, Systoechus gradatus *validus* Bezzi, Systoechus *sinaiticus* Efflatoun.

Tabanus *separatus* Efflatoun, *Tachinosalia aegyptiaca* Villeneuve, Telmatoscopus *squamifer* Tonnoir, Tephritis *desertorum* Efflatoun, Tephritis *pulcherrima* Efflatoun, Thereomyia fasciata *aegyptiaca* Rohdendorf, Thereva *fulvicornis* Kroeber,

Thinophilus *atritarsis* Parent, Thinophilus *maculatus* Parent, Thinophilus *maculosus* Parent, Thinophilus *tinctus* Parent, Thyridanthrax *chionophrorus* Bezzi, Thyridanthrax *tabaninus* Bezzi, Toxophora *aegyptiaca* Efflatoun, Toxophora *leyladea* Efflatoun, Trentepohlia *efflatouni* Pierre, Tritochaeta *apicalis* Villeneuve, Trixiceps *aegyptiaca* Villeneuve, Trypanea (Goniurellia) *rostrata* Hendel, Tylus (Micropeza) *annuliventris* Hendel.

Ulidia *fascialis* Hendel, Usia *bicolor* Efflatoun, Usia *deserticola* Efflatoun, Usia *elbae* Efflatoun, Usia *flavipes* Efflatoun, Usia *grisea* Efflatoun, Usia *inornata* Engel, Usia *lutescens* Bezzi, Usia lutescens *minor* Efflatoun, Usia *minusculus* Efflatoun, Usia *ornata* Engel, Usia *parvula* Efflatoun, Usia *tewfiki* Efflatoun.

Xerophilomyia *nigropicta* Rohdendorf, Xestomyzina *aegyptiaca* Kroeber.

Hymenoptera

Efflatounina gryontoides Priesner, Philanthus (Philoponus) *efflatouni* Mochi.

Lepidoptera

Cucullia *efflatouni* Wiltshire

Thysanoptera

Megeugynothrips efflatouni Priesner.

A REVIEW
OF THE *ANTHOPHORA*-SPECIES OF EGYPT

[*Hymenoptera : Apidae*]

by Prof. Dr. H. PRIESNER

INTRODUCTION

Owing to the difficulties I encountered in trying to identify the Egyptian material of *Anthophora* in the collections of the Cairo and Ain Shams Universities, I had to penetrate more deeply into this matter, especially when I found that quite a number of species of the local collections were no doubt incorrectly named.

With the progress of science, in our particular case with the improvements achieved by finding new distinctive characters and especially in the better relative evaluation of those already known, gained by experience and eye training, there lies upon us the bitter task to criticise and correct our late authorities on this subject who actually did all the spade work that enabled us to start on a considerable higher level of knowledge than that having been at their disposal.

Apart from the relatively excellent work of KLUG (1845) and a number of species described by SPINOLA and — much later — GRIBODO, most of the taxonomic work on *Anthophora* of this country was done by H. FRIESE and A. ALFKEN, their work having been mainly based upon the Apid collections of our late A. ANDRES, while my late friend ALFKEN had also examined specimens he received from the Ministry of Agriculture, Mr. A. ALFIERI and the author. ALFKEN had, obviously with the intention of avoiding the creation of synonyms, identified a number of Egyptian species with such of Asiatic origin. In most of the cases they proved to be different from them.

Although further research may reveal that some of the forms treated as species in this paper, may finally turn out to be races of foreign species of wider pistribution, I am convinced that only a few of them will come into this category. Moreover, I consider it better to treat forms, as e.g. *A. speciosa*, *A. niveiventris*, *A. pretiosa*, a.o., which were varieties by FRIESE, as species than to put them as varieties to such species where they do not belong.

As on previous occasions I am much indebted to Prof. Dr. TAHER SAYED (Ain Shams University), Prof. Dr. MAHMOUD HAFEZ (Cairo University), Mr. ABDEL HAMID IBRAHIM (Ministry of Agriculture) and Mr. A. ALFIERI (General Secretary of the Entomological Society of Egypt) who put the material of the collections in their charge at my disposal for study. To Dr. M. BEIER (Museum Vienna) I owe the permission of examining the large *Anthophora* collection of the Vienna Museum, and I am also much obliged to Dr. G. STEINBACH (Museum Berlin) for the opportunity of studying some types of KLUG and FRIESE, deposited in the Museum Berlin.

GENERAL REMARKS TO THE MORPHOLOGY

The importance of the pubescence or pilosity (length, shape, position and colour) for the differentiation of the species requires careful treatment of the specimens: they should not get wet in the killing bottles and should not be relaxed in the usual relaxing jars. The best method of killing them I consider the use of cyanide; ether should be avoided. After the insects had remained for some hours in the cyanide tube, I used to take them out and put them, i.e. about a score of specimens together, in an empty tube (e.g. 10 by 3.5 cm.) where I left them over night. By this method the specimens get slightly relaxed without getting wet, and the legs can be easily arranged on the setting board, while the pile remains intact. It gave me great satisfaction at the time when ALFKEN (i.l.) stressed the perfect condition of the specimens collected by myself which were treated in the above manner. Apidae the hairs of which are stuck together or discoloured by the killing agent or by intestinal juices of the insects, or which are rubbed, can often not be identified accurately.

The extending of the wings is not absolutely necessary, although the venation can more easily be examined when the wings are expanded. Specimens that are left in the the cyanide bottle too long change the light face colours, the white colour becoming more or less crimson, the yellow becoming orange or brownish.

Pollen of the flowers visited by the bees often adheres in quantities to the tibial scopa. The pollen grains should be carefully taken off the scopa by means of a needle. This procedure prevents the beginner from a faulty judgement of the colour of the tibial pubescence, characteristic to the species.

The shape of the hairs may be much differing. Somewhat roughened or slightly plumose are nearly all hairs of the head, thorax and abdomen, however, in some cases the plumosity of the vertically raised hairs is more conspicuous than usually, well visible already at a 20-fold magnification, as e.g. on tergite II of *A. aegyptiaca*, *A. senescens*, *A. scopipes*, a.o. Also the decumbent hairs of the abdominal fasciae (e.g. in the *quadrifasciata*-group) are thick hairs that appear plumose under *higher* magnification; but these hairs are flattened, and plumose at their sides only, not all around so, as it is the case in the first mentioned species.

The peculiar tufts of hairs of the males of many species, especially the brush on the 5th joint of the middle tarsi, and also the fan-shaped tuft of metatarsus II,

are well known. These tufts may get rubbed off in older specimens; but also in such examples some single black hairs may yet be noticed so that we are rarely in doubt whether a male is "brush-bearer" or not.

The pubescence of the wing cells has hardly been noticed hitherto, but can also be made use of for the characterisation of the species. In most forms at least the anterior parts of the cells situated at the fore margin of the fore wing are set with very short fine microsetae, viz. cells m 1, r 1 and sc. In some species (e.g. *A. savignyi*) the discal cells too show this kind of pubescence. The most extensive pubescence we find in *A. inclyta* and *A. crocea*. Nearly bare is the wing of *A. andresi*. In old specimens these microsetae may be missing (rubbed off), but in this case the fine points of insertion can be seen under the microscope.

Of great importance, particularly for the differentiation of the small uniformly grey species, is the wing venation. Although it is in general as generic character naturally quite uniform, certain details of it are very important for the distinction of species or species-groups. Thus the species of the *quadrifasciata*-group have always a distinctly prefurcal nervulus (vein Cut 1) so that the basal vein and the 2nd abscissa of Cu form a very shortly pedicelled fork. In the species of the other groups the nervulus is mostly interstitial or even slightly postfurcal so that no pedicel is visible. In the older descriptions of paläerctic species I found this character mentioned occasionally by DUSMET only.

With regard to the characterization of the legs in the descriptions of this paper I distinguish between interior and exterior side (face), anterior (inferior) and posterior (upper) side. The exterior side is naturally the one that lies outside when the leg is attached to the body; in many cases this side bears paler and stronger pilosity than the inside. The anterior (inferior) side is in the species having distinctly triangular cross-section of the tibia mostly smooth, flattened or grooved, and limited by two sharp edges. The upper or posterior side (edge) of the tibia is usually sharp-edged or rounded.

The sculpture of the tergites and sternites, also often given in the descriptions, is not a very practical means for the distinction of the species, first of all because just in fresh, well preserved specimens it is often wholly covered by the pubescence; the same applies to the thorax and often the head too. Furthermore, it is very difficult to comparatively describe the puncturation, since it is either dense and fine, or less dense and fine in most cases, and there are no really *striking* differences. Also the foveae on the apical sternites, present in most of the males do not show such apparent peculiarities as e.g. in *Halictus*; moreover, the segments vary as to their state of contraction, and the apical sternites are often not visible in otherwise perfect specimens.

Although even the *shape* of the abdomen could be included as character in the descriptions of a species (e.g. *A. humilis* Spin., or *A. alfkenella* sp. n. which have decidedly a more flattened abdomen than allied species) this character may be misleading, as can be seen from a large series of specimens of one species, and this

again owing to the varying state of contraction of the segments. One should think this point not worth mentioning, but just experienced authors have erred in this respect, and thus I have to draw the attention of the student of this genus to not to mistake species having black-haired basal portions of the tergites with such in which the tergites are wholly covered with pale hairs, but have the segments distended (cf. *A. mucorea* as against *A. byssina*).

The colour shade of the face of species having wholly or partly pale frons, clypeus and labrum is very important as specific character, thus one has to distinguish white, ivory yellow and yellow. That these shades are constant in the species is common knowledge. However, also the dark clypeal spots are important with regard to their shape and extension, and should be described in detail; I found only one species in which a certain variation seems to occur in this respect, provided that I am not mistaken and am still mixing up some very closely allied species (cf. *A. lutulenta*).

As to the terminology of the parts of the head, I should like to remark that the often pale coloured part of the frons joining the base of the clypeus I named: "frontal area"; it is the "Stirnfeld" ALFKEN's or "supraclypeal area" of other authors. What ALFKEN termed "Wangen" (-genae) should not bear this name but may better be called "sides of frons" or "facial triangles"; this part is situated between the lateral margins of the clypeus and the inner orbits, and is usually triangular, more or less attaining the fore angles of the clypeus. The part called "genae" in the descriptions of this paper is identical with FRIESE's "Wangen" and ALFKEN's "Wangenanhang" (= genal appendix), i.e. the space between the eyes and the base of the mandibles, which is either rudimentary or linear in many species (e.g. groups V, VII) or distinctly developed, representing a small smooth and shining area (cf. groups I and II). In FRIESE's monograph we find the species even combined to subgenera on the base of the development of these "Genae"; COCKERELL's "intermalar space" is the same, if I am not mistaken, because the literal meaning of this term suggests something else. In judging the greater or lesser degree of development of this space between apex of eyes and base of mandibles the student can easily be mislead, and it was for this reason that in the keys I gave more importance to other characters, though I remain well aware of the systematic importance of this character. The keys should not be a copy of the system but a taxonomic help for identification.

With the new species it was sometimes difficult to determine which male belonged to which female, and this owing to the rather marked sexual dimorphism combined with the great similarity of many species. This dimorphism manifests itself mainly in the shape and markings of the face, the antennae, the form, sculpture, pubescence (and colour of it) of the legs and also the body. However, in many cases just the equality or similarity of the hairs of the tergites (II-IV) proved to be an indication of the specific identity of certain specimens of different sex. Details of the wing venation (nervulus !) and the cell pubescence are equal in both sexes. On the other hand, there seem to exist a few cases in which the dimorphism is parti-

cularly strongly marked; thus I am convinced that the nearly wholly black *A. vidua* Kl. and the pale *A. boops* are the sexes of one single species. *A. maculigera* sp. n. might also be the male of a black female, but this remains a guess for the present.

SYSTEMATIC AFFINITIES OF THE SPECIES

In FRIESE's work "Bienen Europas" (pp. 18-22) we find the genus *Anthophora* (*Podalirius*) divided in four subgenera and the larger ones of these again in groups. Apart from the subgenus *Habropoda* Sm. the subgenera (*Paramegilla*, *Amegilla* and *Anthophora*) are connected by various transitional species so that it looks to me more correct to arrange the bulk of *Anthophora* in a series of groups of equal value. The final system in this respect has to be made on a world wide base, it is not the task of this paper. However, on comparing the Egyptian species with one another and with a great number of those of Eurasia I could see that there appear quite a number of natural groups which, as it seems to me, show much better the natural affinities of the species than the former grouping that took into account, apart from the length of the genae, only or mainly the colour and pattern of the pubescence.

It is obviously better to give more importance to the wing venation and the male characters (without disregarding the pile of the body), and group the species according to these characters *in combination* with the development of the genae and the pattern of the hair-covering.

Thus, the Egyptian species can be tentatively grouped as follows :

GROUP I (*fulvitarsis*) : Larger species with raised pilosity and distinctly plumose hairs of tergit II. Genae developed. Nervulus interstitial. Male : Metatarsus II with fan, joint 5 of tarsi II with brush. Tergite VII with 2 fine comparatively long teeth which are separated by an arched excavation. — Species : *aegyptiaca* DT. and Fr., *senescens* Lep.

GROUP II (*mucida*): Mainly large species with raised pilosity at least on tergites I and II. Genae developed. Nervulus almost always interstitial, never distinctly prefurcal. Fan of metatarsus II sometimes, brush of tarsal joint 5 almost always, developed. Tergite VII of male with more or less slender terminal plate, not with separated teeth. — Species (in subgroups) : (a) *albosignata* Fr., *arabica* sp. n., *atriceps* Pér., *atricilla* Ev., *cinereiceps* Alfken, *desertorum* sp. n., *dispar* Lep., *facialis* sp. n., *lanata* Kl., *mucida* Grib., *niveiventris* Fr., *pretiosa* Fr., *speciosa* Fr; (b) *flabella* a sp. n., *scopipes* Spin., *spinolana* sp. n.; (c) *alfierii* Alfken, *hispanica* F.

GROUP III (*ambigua*) : Moderately large species (ca. 10 mm.), with raised pilosity of the abdomen, narrower genae and interstitial nervulus. Males with two small teeth of segment VII separated by a roundish or straight emargination. Hind legs enlarged in some cases and armed with teeth. Mid tarsi with joint 5 slender and

without brush. — Species : *extricata* sp. n., *moricei* Fr., *priesneri* Alfken, *wegelini* Fr., *zanoni* Grib.

GROUP IV (*blanda*) : Genae not developed. Pilosity of abdomen short. Nervulus interstitial. Posterior legs of male strongly enlarged, tibiae and metatarsi armed. Tergite VII with two median carinae, 2 short teeth and a lateral excavation forming two more teeth, i.e. quadridentate. — Species: *blanda* Per.

GROUP V (*lutulenta*) : Small species without distinct genae, with decumbent (or very scarce raised) abdominal pilosity. Male usually with brush on segment 5 of tarsi II, the latter being often enlarged. Tergite VII with 2 *triangular* teeth that are separated by a triangular excision, seldom with 1 or 2 small tubercles in addition; tergite VII with median longitudinal carina. Nervulus almost always interstitial.— Species : *alfkenella* sp. n., *concinna* (Kl.), *elbana* sp., n., *fallaciosa* sp. n., *fayoumensis* sp. n., *galalensis* sp. n., *helouanensis* sp. n., *humilis* Spin. (?), *lutulenta* (Kl.), *mellina* sp. n., *perlustrata* sp. n., *selecta* sp. n., *shagrensis* sp. n., *tenella* (Kl.), *tridentella* sp. n.

GROUP VI (*inclyta*) : Genae not developed. Pilosity of the abdomen mainly decumbent, short. Nervulus interstitial. Male with tergite VII *tridentate* or trilobed, median tooth broader, blunt or rounded, and more protruding than the two lateral smaller teeth. Metatarsus III with a hump or tooth at its inferior edge. — Species : *alternans* (Kl.), *armata* Fr., *boops* Alfken, *concolor* Alfken, *fumipennis* Alfken, *inclyta* Wlk., *maculigera* sp. n., *oraniensis* Lep. (?), *semirufa* Fr., *valga* (Kl.), *vidua* (Kl.).

GROUP VII (*quadrifasciata*) : Pilosity of the abdomen short and mainly decumbent, either unicolorous (white or greyish) or with marginal decumbent fasciae of paler colour. Genae absent. Orbits convergent anteriorly. Male always without brush on joint 5 of tarsus II, and with slender ultimate joint. Nervulus distinctly prefurcal. Tergite VII of male with two small teeth. — Species : *albigena* Lep., *andresi* Fr., *byssina* (Kl.), *candidella* sp. n., *carnea* Grib., *crocea* (Kl.), *deceptrix* sp. n., *klugi* n. n., *latizona* Spin., *litorana* sp. n., *magnilabris* Fedt., *montivaga* Fedt., *mucorea* (Kl.), *nivosella* sp. n., *omissa* sp. n., *pipiens* Mocs., *punctifrons* Wlk., *quadrifasciata* Vill., *savignyi* Lep., *torensis* sp. n.

GROUP VIII (*gracilipes*) : Female about as in group VII, male with unusually elongated hind legs in which the tarsi are longer than the tibiae. Nervulus prefurcal. — Species : *tarsalis* sp. n.

KEY TO THE SPECIES

Males

1 (4) Ultimate joint of fore and middle tarsi with black hairs on both sides forming a fan or brush.

2 (3) White fasciae on tergites II and III almost decumbent. Pilosity of thorax and tergites I and II yellow-grey or grey. Middle and hind tibiae at the posterior margin clothed with decumbent or semi-erect whitish hairs. Clypeus with fine shallow but more distinct puncturation than in *pretiosa*. Width of thorax about 6 mm. .... **atricilla Ev. ssp. aegyptorum nov.**

3 (2) White fasciae on tergites II-IV composed of thin, somewhat raised hairs. Thorax and tergites I-(II) with ferruginous hairs. Pilosity towards apex of middle and hind tibiae long and raised. Width of thorax about 7.5 mm.... ..... **pretiosa Fr.**

4 (1) Ultimate joint of fore tarsi without a brush of dark hairs.

5 (55) Ultimate joint of middle tarsi with conspicuous brush of blackish hairs, or at the sides with slightly raised black hairs.

6 (54) Apical joint of hind tarsi shorter than the metatarsus.

7 (36) Larger species, surpassing a length of 11 mm.

8 (29) Mandibles dark, without yellow or whitish spot at base.

9 (12) Ground colour of face black. Body length 11-12 mm.

10 (11) Face and under side of body with black pilosity. Tergites I-III with more or less pale raised hairs, without fasciae ..... **facialis sp. n.**

11 (10) Face at least on labrum with whitish hairs. Tergites I and II of abdomen with white-grey, the rest with black raised hairs. Metatarsus II with dark fan. Brush on joint 5 of tarsi II weak. Thorax with grey pilosity .... **atriceps Pér.**

12 (9) At least the clypeus in the middle more or less broadly yellow or whitish.

13 (16) Sides of frons dark on the ground. Face with white, at the orbits with black, pilosity. Metatarsus II without fan.

14 (15) Labrum almost or wholly black. Tergites from III onwards with almost only black hairs. Hind tibiae and metatarsus III with with many black hairs among the pale ones, also at the margins. Body length 13.5 - 14.5 mm... ..... **cinereiceps Alfken**

15 (14) Labrum yellow with dark sides. The whole body clothed with long raised grey-white hairs which are on tergites from III onwards mixed with black hairs. Hind tibiae and metatarsus III at the upper margin with long, at the apex with short, whitish hairs. Length 14.5 - 16 mm..... ..... **lanata (Kl).**

16 (13) Sides of frons yellow or whitish, or the orbits with pale line.

17 (20) Metatarsus III exteriorly strongly convex, like swollen, shining.

18 (19) Vertex, thorax and tergite I with ferruginous pilosity, the remaining tergites evenly clothed with grey-white hairs, only on tergite V with black hairs between the others ..... **disparilis Fr.**

19 (18) Tergites III and IV wholly or for the major part clothed with black hairs.

a (b) Thorax and tergite I clothed with testaceous hairs, profusely mixed with black hairs; tergite II with grey hairs in basal portion, tergites III and IV with black, or only few white, hairs ..... **dispar Lep.**

b (a) Thorax and tergite I with ferruginous pilosity, sparingly mixed with black hairs; tergite II with pale hairs only, III and IV with black, at the hind margin with long white, hairs ..... **speciosa Fr.**

20 (17) Metatarsus III normal, not swollen exteriorly.

21 (22) Metatarsus II with conspicuous black fan, otherwise with long, pilosity. Thorax clothed with grey-white to grey-yellow hairs. Brush on joint 5 of mid tarsi conspicuous. Tergite VII with 2 small teeth .... **senescens Lep.**

22 (21) Metatarsus II without fan, only with scattered long hairs. Tergite VII of different structure.

23 (24) Thorax mainly with grey-white pilosity. Tergite VII with slight triangular excision at apex. Brush on joint 5 of tarsi II weak. Orbits with fine yellow line only. Length 11 - 11.5 mm. ..... **desertorum sp. n.**

24 (23) Thorax in fresh specimens with reddish-brown or ferruginous pilosity. Broader species of at least 12 mm. length.

25 (26) Genae linear ..... **cf. tenuiciliata Alfken**

26 (25) Genae well developed.

27 (28) Ground of face whitish, sides of frons distinctly triangularly whitish. Antennal joint 3 longer than the three following joints together. Tergite VII truncate at apex, and somewhat emarginated, angles slightly protruding ..... **albosignata Fr.**

28 (27) Ground of face yellow, sides of frons only narrowly yellow. Antennal 3 as long as the three following joints together. Tergite VII truncate at the apex, apical margin slightly reflexed ..... **mucida Grib.**

29 (8) Mandibles yellow at base, or with yellow spot.

30 (35) Ground of metatarsi II and III brown-red and clothed with such or ferruginous hairs, often also the tibiae reddish-brown instead of black, and with such hairs. Abdominal fasciae wanting or very fine. Brush of joint 5 of tarsi II large, circular. Length 14-15 mm.

31 (34) Face white on the ground.

32 (33) Hind margins of tergites not transparent. Pilosity of thorax and tergites I and II white-grey. Fasciae practically absent. Metatarsus II somewhat less slender. Nervulus interstitial. Tergite VII dark, the produced portion broader, with distinct lateral apical angles ..... **spinolana sp. n.**

33 (32) Hind margins of tergites transparent, yellow-grey to ferruginous. Pilosity of thorax and tergites I and II grey-yellow. Tergite II mostly with fine white fascia. Nervulus very slightly prefurcal. Tergite VII narrower, angles rounded ..... **scopipes Spin.**

34 (31) Face yellow. Tergites II-III (-IV) at the sides with very fine white fasciae, the hind margins yellowish transparent. Tergite VII reddish, narrowly produced, slightly emarginated at middle of apical margin. Nervulus slightly prefurcal ..... **flabellata sp. n.**

35 (30) Legs blackish on the ground, only the tarsi paler. Plate of tergite VII with 2 acute ferruginous teeth. Metatarsus II exteriorly in apical half with fan of black hairs. At least tergites II and III in fresh specimens with a narrow white fascia. Face yellow, clypeus strongly protruding. Length 15-17 mm ..... **aegyptiaca D. and Fr.**

36 (7) Small species of 6-10 mm. length.

37 (42) Hind tibiae triangular in cross-section, with a tooth-or lobe-like projection inferiorly at the apex. Tergite VII without longitudinal carina.

38 (39) Length 8-10 mm. Hind tibiae with apical spine. Metatarsus of hind leg exteriorly with black hairs, that of mid leg exteriorly at base with few white hairs. Fasciae of abdomen narrow, whitish or pale yellowish. Clypeus densely punctured ..... **fulvodimidiata Dours**

39 (38) Length 6-8 mm. Apex of hind tibiae with small lobiform tooth, interior face of tibia smooth, bare, shining. Pilosity brown-red to ferruginous. Clypeus with flat median convexity, but without lateral foveae, shining. Nervulus indistinctly prefurcal. In front of the abdominal fasciae there are no pale hairs on tergites II and III.

40 (41) Calcaria of tibiae II dark, of tibiae III margined with black. Metatarsus III exteriorly clothed with black or dark brown hairs .. **concinna (Kl.)**

41 (40) Calcaria of middle and hind legs yellow. Metatarsus III exteriorly at base with some reddish hairs. (Hedjas) ..... **concinna hegasica nov.**

42 (37) Hind tibiae rounded at the apex or the inferior angle pointed but without distinct tooth-or lobe-like production. Interior face of tibiae punctured and pilose, not wholly smooth. Tergite VII with fine longitudinal carina. Nervulus interstitial or slightly postfurcal. Body above with grey or grey-yellow pilosity.

43 (46) Fore margin of yellow clypeus with a brace-shaped transverse keel and, connected with it, a median carina towards base, forming two large lateral foveae.

44 (45) Tergites of the abdomen also in front of the yellowish fasciae with some decumbent yellowish pilosity. Metatarsus III interiorly with ferruginous hairs ..... **fayoumensis sp. n.**

45 (44) Tergites in front of the fasciae only with black short raised or semidetached hairs. Metatarsus III with brown pilosity within. Joint 5 of tarsi II without visible brush of hairs ..... **cf. mellina sp. n.**

46 (43) Clypeus pale yellow or white, at most with broad median convexity, without carinae or lateral impressions behind fore margin.

47 (48) Metatarsus III interiorly with yellowish or testaceous hairs. Whitish or yellow pilosity present in front of fasciae. Width of head at least 3.5 mm. (1) Pilosity of body grey to slightly yellow grey ..... **lutulenta (Kl.)**

48 (47) Metatarsus III with reddish-brown or blackish hairs within. Fasciae narrower. Pale pubescence in front of fasciae scarcer. Flagellum below scarcely paler or only brown, not ferruginous.

49 (50) Face white. Excision on tergite VII triangular. Nervulus slightly postfurcal. Vertex, thorax and tergite I in fresh specimens with yellow pilosity ..... **alfkenella sp. n.**

50 (49) Face yellow.

51(52,53) Marginal excavation of tergite VII broad, but not deep, about brace-shaped. Antennal 3 scarcely longer than broad ..... **elbana sp. n.**

52(51,53) Apical excavation of the dark tergite VII almost straight or forming a shallow arch, at the sides with 2 small dark teeth; in the middle of the apical margin there are 2 small tubercles. Antennal 3 little longer than broad ..... **perlustrata sp. n.**

53(52,51) Tergite VII testaceous, with 2 triangular teeth separated by a triangular excision. Antennal 3 about 1.5 times as long as broad. Fasciae of tergites very narrow ..... **fallaciosa sp. n.**

54 (6) Middle and particularly hind *tarsi* very long, joint 5 longer than the metatarsus. Tibiae and metatarsi with teeth. Margins of tergites pale transparent. Nervulus slightly prefurcal. Body length 9 mm., length of hind tarsi about 7 mm. ..... **tarsalis sp. n.**

55 (5) Ultimate joint of middle tarsi without brush, only sometimes with a few adpressed black hairs, but in this case joint 5 much widened towards apex.

56 (75) Hind legs with certain special characters : either metatarsus with apical or inferior tooth or dilatation near middle or inferior edge, or femora very strongly enlarged, with or without teeth, or the tibiae armed with a tooth.

57 (66) At least tergites II and III without long raised hairs. Metatarsus III at the inferior edge with a hump or a pointed or blunt tooth.

58 (59) Hind tibiae and tarsi interiorly and exteriorly with black pilosity. Thorax and abdominal tergite I with red or ferruginous pilosity. Metatarsus III at the inferior edge with blunt tooth ..... **semirufa Fr.**

59 (58) Hind tibiae exteriorly with pale pilosity or otherwise different.

60 (61) Thorax and tergite I clothed with grey or yellow-grey hairs, tergites II-III (-IV) at the sides of the hind margins with partial fasciae or wedge-shaped hair-spots. Metatarsus III with about rectangular tooth behind middle. Length 16 mm ..... **maculigera sp. n.**

(1) If head less than 3.5 mm. broad, and black hairs on joint 5 of middle tarsi scarce cf. *A. tenella* (Kl.)

61 (60) Tergites II and III not with cuneiform lateral hair-spots, but with full fasciae or without any.

62 (63) Pilosity of thorax whitish, fasciae on tergite V and VI interrupted in the middle. Tooth of metatarsus III obtusely angled. Tergite VII sinuated laterally, the sinuations separated each by a small tooth. .... **boops Alfken**

63 (62) Thorax above and base of tergite I with yellowish or reddish hairs, or the whole abdomen with ferruginous or yellow hairs.

64 (65) Metatarsus III broad, tooth large, blunt. Tergite VII medially at the apical margin rounded, at each side with a tooth. Hind tibiae at the in terior face with black hairs. Wings infumated ..... **inclyta Walker**

65 (64) Metatarsus III with somewhat pointed tooth. Tergite VII emarginated at apex. Hind tibiae interiorly with black hairs only at base. Wings almost hyaline..... **cf. valga (Kl.)**

66 (57) Tergites from II onwards, besides the decumbent fasciae, with raised pilosity.

67 (68) Hind femora strongly enlarged; trochanters dentate; hind tibiae club shaped, their interior face carinated, with blunt angle; metatarsus III with large pointed tooth, below. The white fasciae narrow, well defined. Thorax clothed with yellow to ferruginous hairs. Clypeus with black central spot ..... **blanda Pér.**

68 (67) Metatarsus III without tooth. Thorax more greyish. Fasciae less well defined.

69 (70) Hind legs enlarged, without conspicuous teeth. Tergite VII with 2 small pointed teeth. Sides of frons broadly V-shaped white. Labrum pale ..... **extricata v. clavatipes nov.**

70 (69) Hind femora and (or) tibiae with blunt or pointed teeth.

71 (74) Hind tibiae at the inferior apex with long pointed tooth.

72 (73) Hind femora sulcate at hind margin, at base with a short blunt tooth. Grey pilosity of thorax with slight yellowish tinge. White spot on sides of frons triangular ..... **priesneri Alfken**

73 (72) Hind tibiae at base with pointed tooth. Pilosity grey. The yellow portion the interior orbits is a more or less narrow stripe .... **zanoni var. borgensis nov.**

74 (71) Hind tibiae at the apex without long lower tooth. Hind femora in the middle with pointed tooth ..... **cf. crassipes Lep.**

75 (56) Hind legs without remarkable tooth-like structures, at most the apex of the hind tibiae exteriorly slightly pointed or reflexed.

76 (77) Ground colour of abdomen ferruginous with dark posterior tergites or dark spots on them. Tergites I - V with broad white fasciae. Length 13-15 mm. ..... **carnea Grib.**

77 (76) Tergites of abdomen dark on the ground, at most the margins pale transparent, or only tergite I partly reddish; seldom in immature specimens the basal segments somewhat brown-red.

78 (87) Ground colour of head black.

79 (84) Very large species of 17-21 mm. length.

80 (81) Metatarsus II with triangular fan of black hairs which are curled at the tips. Pilosity of body ferruginous (or red) and black .... **hispanica F.**

81 (80) Metatarsus of mid leg without large fan of hairs. Head almost wholly with black hairs.

82 (83) Thorax and tergites I and II with raised reddish or yellow hairs, the remaining tergites with short raised black hairs ..... **alfierii Alfken**

83 (82) Thorax and tergite I with yellow to white-yellow hairs, II and following tergites with black hairs ..... **armata tetra Fr.**

84 (79) Smaller species, having a length of 11-12 mm. and almost vertically raised pilosity on the whole body.

85 (86) The whole face and under side of body covered with black hairs, only vertex, thorax and abdominal tergites I-III with grey hairs .... **cf. facialis sp. n.**

86 (85) Face with grey or whitish hairs too, particularly at the lower portion. Metatarsus II with distinct brush of black hairs .....**cf. atriceps Pér.**

87 (78) Clypeus wholly or partly yellow or white, sometimes only at the fore margin.

88 (91) Large species of 16-18 mm. length.

89 (90) Thorax and tergites I and II with grey pilosity. Fascia on III and IV very narrow, disks wholly dark. Clypeus, sides of frons and frontal area yellow, clypeus with 2 small black dots ..... **cf. vetula (Kl.)**

90 (89) Tergite IV wholly, tergites V and VI laterally with raised white pilosity, basal tergites wholly dark .....**nubica (Kl.).**

91 (88) Smaller species of other coloration.

92 (95) Species of 14-16 mm. length in which thorax and tergites I or II (or only 1) are clothed with reddish or yellow hairs, the rest of the abdomen with black hairs. White fasciae very fine. Genae linear.

93 (94) Thorax and tergites I and II with ferruginous to reddish-brown, the remaining tergites with black, pilosity. Fine fasciae present on tergites I and II ..... **cf. tenuiciliata Alfken**

94 (93) Colour similar, but fasciae developed on tergites II-IV (-V) .... **oraniensis Lep.**

95 (92) Either the thorax not with reddish pilosity, at most yellowish-grey, or, if ferruginous, then smaller species; or abdomen with broader white fasciae.

96 (147) At least tergites II and III without distinctly raised pilosity, or with only quite short, black, semi-erect hairs; or with scattered white or black hairs only.

97 (136) Antennal joint I white or yellow in front (beneath) or with such longitudinal spot.

98 (101) Apical margin of tergite VII with *three* short teeth, a median blunt tooth and two lateral short triangular, or three very small, teeth.

99 (100) Length 12-15 mm. Hind tibiae slightly curved. Abdominal fasciae broad, illdefined in front, widened laterally. Fore tarsi short .... **alternans (Kl.)**

100 (99) Length 7.5-8 mm. Hind tibiae straight. Tergites in front of the scarcely marked fasciae with grey pilosity. Antennae dark. Joint 5 of mid tarsi somewhat thickened, with dark hairs, but without brush. Clypeus transverse. Tergite VII with three very small teeth ..... **tridentella sp. n.**

101 (98) Apical margin of tergite VII with two spiniform or triangular teeth, rarely with slender conical reddish apical plate, bearing indistinct teeth.

102 (107) The pale pilosity of body and legs ferruginous or reddish. Fasciae testaceous to ferruginous. Clypeus and labrum yellow. Flagellum more or less ferruginous below.

103 (104) Broadly built species of 9-10 mm. length. Clypeus without carinae. Tergites in front of the fasciae too with decumbent pale hairs. Wings slightly infumated, cells pubescent. Scutellum smooth, shining in front. Nervulus slightly prefurcal ..... **crocea (Kl.)**

104 (103) Slenderer, smaller species in which the clypeus shows a raised fore margin and median keel, and two shallow foveae. Scutellum densely punctured. Tarsal joint 5 of mid legs thickened, with a few black hairs but without brush. Nervulus interstitial or slightly postfurcal.

105 (106) Tergites II-IV in front of fasciae with black pilosity only. Antennal joint 4 not twice as broad as long. Metatarsus III slightly bent at base, interiorly with brown hairs. Labrum in the middle of the fore margin slightly produced ..... **mellina sp. n.**

106 (105) Tergites II-IV not only at the hind margin, but also in front of the densely haired fasciae, with not very dense decumbent ferruginous hairs. Antennal 4 twice as broad as long. Metatarsus straight, with golden-yellow hairs within and without ..... **cf. fayoumensis sp. n.**

107 (102) The pale pilosity white or grey, at most on head and thorax yellowish; the fasciae never testaceous or ferruginous, in any case the posterior fasciae white. Nervulus slightly prefurcal.

108 (125) Metatarsus III exteriorly with black hairs only, at most the extreme base or upper margin with single white hairs.

109 (116) White fascia of tergite V interrupted in the middle, or tergite V wholly black.

110 (111) Flagellum ferruginous below. Labrum large, as long as broad or appearing even elongate. Clypeus strongly protruding. ..... **magnilabris Fedt.**

111 (110) Flagellum dark.

112 (113) Vertex and thorax with ferruginous pilosity. Anterior fasciae with yellowish tinge. Excision between teeth of tergite VII arched .... **quadrifasciata Vill.**

113 (112) Vertex and thorax with yellow-grey to white-grey pilosity. Fasciae white. Excision between teeth of tergite VII straight for some distance.

114 (115) Fasciae of abdomen narrower. Posterior tarsi slenderer. Face with slight yellow tinge ..... **litorana sp. n.**

115 (114) Fasciae broader. Posterior tarsi broader. Face white ..... **klugi n. n.**

116 (109) Fascia on tergite V not interrupted in the middle.

117 (122) Colour of face pale yellow.

118 (119) Head, thorax and tergite I without black hairs, at most in front of the scutellum with single black hairs. Antennae somewhat stouter, flagellum ferruginous below. (Arabia) ..... **farinosa (Kl.)**

119 (118) At least hairs of thorax and tergite I mixed with a great number of black hairs.

120 (121) Flagellum dark brown to black, length of antennae 4-4.5 mm. Joint 3 nearly or wholly twice as long as broad, joint 5 distinctly longer than broad. Metatarsus III mostly with distinct spot of white hairs exteriorly at base ..... **cf. savignyi Lep.**

121 (120) Flagellum ferruginous below, length of antennae less than 4 mm., joint 3 scarcely to 1.5 times longer than broad, joint 5 not or very slightly longer than broad. Metatarsus III black exteriorly or with only single white hairs at base. Smaller species ..... **punctifrons Wlk.**

122 (117) Face white to ivory-white. Flagellum dark brown to black, or only joints 3-4 testaceous.

123 (124) Tergites of abdomen almost evenly clothed with white-grey hairs. Nervures of wing at least basally yellow. Joint 1 of antennae at most with pale dot. Metatarsus III black ..... **cf. byssina (Kl.)**

124 (123) Tergites of abdomen in front of the fasciae clothed with black hairs. Veins dark. Joint 1 of antennae whitish beneath. Metatarsus III for about 1/3 of its length with white hairs exteriorly ..... **albigena Lep. ssp. afra nov.**

125 (108) Metarsus III exteriorly with white hairs either all along or at least for half of its length; these hairs may be sometimes slightly raised.

126 (131) Species with dense white or greyish pilosity in which the whole tergites are white or grey pubescent in front of the fasciae, the ground being not or scarcely visible; in the latter case, no black hairs present.

127 (130) Smaller species of 6.5-8 mm. length. Flagellum mostly ferruginous below.

128 (129) Antennae longer and slenderer, joints 5-13 distinctly longer than broad. The whole face pale yellow ..... **tenella (Kl.)**

129 (128) Antennae stouter. Labrum, mandibles and clypeus, the latter distally, white ..... **nivosella sp. n.**

130 (127) Larger species of 8.5-9.5 mm. length. Clypeus, labrum, mandibles and frontal area yellow. Antennae long, flagellum below at most brown. Similar to *byssina* ..... **deceptrix sp. n.**

131 (126) Tergites in front of the fasciae partly with black pilosity.

132 (135) Clypeus and sides of frons white or yellow-white. Flagellum dark.

133 (134) Sternites dark, without white fringe of hairs at the sides. Joint 5 of middle tarsi slender. Nervulus prefurcal ..... **cf. albigena Lep.**

134 (133) Sternites with white hairs at the sides and testaceous hairs in the middle. Joint 5 of middle tarsi thickened towards apex, but without brush. Metatarsus II with yellow hairs within. Nervulus interstitial .... **cf. helouanensis sp. n.**

135 (132) Clypeus pale in front only, two basal spots and sides of frons beneath the white pile black. Face with very dense but short white hairs. Nervulus prefurcal ..... **latizona Spin.**

136 (97) Antennal joint 1 wholly black, or brown beneath, sometimes with a set of white hairs.

137 (142) Tergites II-III (-IV) also in front of the fasciae with more or less dense pale pilosity, the fasciae only somewhat more densely pubescent than the disks.

138 (141) Metatarsus III exteriorly clothed with black hairs, only at base with single white hairs. Sides of face dark, clypeus yellow or white.

139 (140) Margin of tergite VII between the two teeth nearly straight, teeth pointed. Sternite VI somewhat shining, densely punctured. Face white, with very dense white pile ..... **byssina (Kl.)**

140 (139) Margin of tergite VII between the less acute teeth arched (concave). Face yellow, with less dense and shorter white pilosity. Sternite VI smooth towards apex, polished, scarcely punctured ..... **mucorea (Kl.)**

141 (138) Metatarsus III exteriorly wholly clothed with white hairs, all joints of middle tarsi exteriorly with white hairs. Face with dense white pilosity. Antennae dark. Thorax without black hairs. Clypeus more strongly protruding than in *byssina* ..... **cf. deceptrix sp. n.**

142 (137) Tergites in front of the fasciae more or less clothed with black hairs.

143 (144) Pale band of tergite V interrupted in the middle, or the tergite nearly wholly black, with a few white hairs at the sides.

a (b) Metatarsus II with white hairs at the extreme base, metatarsus III with black hairs only. Tergite V with a few white hairs at the sides. ..... **andresi Fr.**

b (a) Metatarsi II and III exteriorly all along with white hairs. Tergite V with white fascia broadly interrupted in the middle .... **montivaga Fedt.**

144 (143) Tergite V all across clothed with white hairs, or with a complete white fascia apically.

145 (146) The whole metatarsus III and also joints 2-3 (-4) of hind tarsi exteriorly with white hairs. Clypeus yellow, with large square black basal spots. Thorax with many black hairs intermixed ..... **pipiens Mocs.**

146 (145) Metatarsus III only at base with single white hairs. Clypeus pale yellow. Sternite VI strongly shining ..... **cf. mucorea (Kl.)**

147 (96) Tergites from II onwards, besides the fasciae which may be present or absent, with distinctly raised pilosity. Nervulus almost always (except in *nivosella*, 7.5-8.5 mm.) interstitial or slightly postfurcal.

148 (151) Labrum black.

149 (150) Slenderer species. Joint 5 of middle tarsi without raised black hairs. Tergites I-IV with marginal fasciae of semi-erect white hairs. Antennal 3 thin, abruptly conically widened at apex, longer than the three following joints together. Metatarsus III slender, slightly curved, upper edge slightly convex. Venter with grey pilosity ..... **arabica sp. n.**

150 (149) Broader species. Joint 5 of middle tarsi with some raised black hairs. Tergites without white fasciae, only some white raised hairs at the sides of tergites III and IV. Antennal 3 less abruptly thickened. Metatarsus III slender, parallel-sided. Venter with black pilosity .... **cf. cinereiceps Alfk.**

151 (148) Labrum for the major part or wholly yellow or white.

152 (153) Larger species, length 14-16 mm. The whole body uniformly clothed with long white-grey hairs, without fasciae. Antennal 3 less slender than in *arabica*, scarcely as long as the three following joints together ..... **cf. lanata (Kl.)**

153 (152) Smaller species.

154 (155) Clypeus elevated in front and medially, with two lateral foveae, yellow. Tergite VII with median carina ..... **cf. fayoumensis sp. n.**

155 (154) Clypeus without distinct impressions.

156 (157) Tarsal joint 5 of mid leg thickened, but without black hairs laterally. Length 9 mm. ..... **helouanensis sp. n.**

157 (156) Joint 5 of middle tarsi slender or, if slightly thickened, then pilosity of face very dense, white.

158 (167) Mandibles black or with small yellow line or dot at the broad base. Sides of face with pale, mostly V-shaped, distal spot.

159 (162) Antennal joint 3 only twice as long as broad, shorter than 4 and 5 combined. Somewhat smaller, 8-9 mm. Cells near for margin of wing more or less distinctly pubescent (microsetae). Mandibles mostly black.

160 (161) Thorax with a few black hairs between the whitish hairs. Tergites of the abdomen without black hairs. Mandibles black ..... **moricei Fr.**

161 (160) Thorax with many dark hairs intermixed. Tergites with a few black hairs. Mandibles with small yellow dot ..... **moricei var. nigripilis nov.**

162 (159) Antennal joint 3 as long as or longer than 4 and 5 combined. Somewhat larger species. Mandibles mostly with pale dot.

163 (164) Thorax and abdominal tergites with whitish hairs only. Antennal 3 as long as 4 and 5 together ..... **wegelini Fr.**

164 (163) Thorax with some black hairs between the pale ones. Tergites (II-) III - V with many raised black hairs mixed with the white hairs. Antennal joint 3 thinner, somewhat longer than 4 and 5 combined. Pilosity of thorax with very slight yellowish tinge.

165 (166) Hind legs normal ..... **extricata sp. n.**

166 (165) Hind legs somewhat incrassate ..... **extricata var. clavatipes nov.**

167 (158) Mandibles for the major part yellow or whitish. Flagellum often ferruginous below. Veins often yellowish ..... **cf. 126 ff., 143-146.**

Females

1 (116) At least the tergites II and III of the abdomen with decumbent pilosity; if it is somewhat raised the hairs are either very short or only semi-erect.

2 (9) Head, thorax and abdomen covered with black hairs, seldom the propodeum or only tergites I or II, or IV or V conspicuously white-haired. Length of body 14-19 mm.

3 (6) Abdomen without white pilosity. Ground of face and clypeus dark.

4 (5) Wings strongly infuscated, blackish-brown with violet lustre. 19 mm ..... **fumipennis Alfken**

5 (4) Wings only slightly shaded. 14-17 mm..... **concolor Alfken**

6 (3) At least one of the abdominal tergites with a white transverse fascia.

7 (8) White fasciae on tergite I or also II. Legs black and clothed with black hairs. 16-18 mm..... **vidua (Kl.)**

8 (7) Tergite IV wholly with decumbent white, V laterally and propodeum with raised white, pilosity. Clypeus yellow, with two large black spots. Length 17-18 mm. ..... **nubica Lep.**

9 (2) Head, thorax and abdomen showing a pilosity different from that of the species sub : 3-8.

10 (35) Large species, having a length of 16-20 mm.

11 (14) The whole body covered with ferruginous pilosity.

12 (13) Tergites II-IV almost bare. Clypeus and legs ferruginous, thorax and at least tergite I of the abdomen ferruginous on the ground. Abdomen with pale postero-marginal fasciae ..... **carnea Grib.**

13 (12) The whole abdomen with fine, adpressed, ferruginous pilosity. Abdomen without fasciae. Wings infumated. 16 mm. ..... **inclyta Walker**

14 (11) Not the whole body with ferruginous pilosity.

15 (18) Posterior margins of tergites rather broadly yellowish transparent. At least tibiae partly and tarsi with ferruginous or pale brown ground-colour.

16 (17) Tergites from III onwards with black pilosity. Tergite III without fine pale marginal line of white hairs ..... **scopipes Spin.**

17 (16) Tergite III with fine pale marginal fascia; tergite V with ferruginous pilosity at middle ..... **flabellata sp. n.**

18 (15) The posterior margins of the tergites not pale and transparent but black brown or black like the rest of the tergites. Legs darker.

19 (20) Clypeus yellow, with two black spots fused with black sides of frons. Tergites (I-) II-III with white postero-marginal fascia, tergites IV and V with white pilosity at the sides only. Metatarsus III white-haired at base only, rest with black hairs. Genae present .... **atricilla ssp. aegyptorum nov.**

20 (19) Integument of head quite dark.

21 (24) Head for the major part covered with black hairs.

22 (23) Thorax and tergites I and II with yellow or ferruginous, the following tergites with black, pilosity. Hairs on tergite II plumose. Tibiae and tarsi predominantly with black pilosity. Wings not infuscated .... **cf. alfierii Alfken**

23 (22) Thorax and tergite I with yellow pilosity. Wings strongly darkened. 20 mm. ..... **armata v. tetra Fr.**

24 (21) Pilosity of head pale or partly brown, without or with few black hairs.

25 (30) Tergites without white fasciae.

26 (27) Head and tergite I with yellowish or ferruginous, the remaining tergites with black, pilosity. 15-17 mm. ..... **semirufa Fr.**

27 (26) Tergites I and II with pale pilosity, the remaining tergites with black pilosity.

28 (29) Thorax and tergites I and II with yellow or ferruginous pile. 19-20 mm. ..... **cf. hispanica F.**

29 (28) Thorax and tergites I and II with grey pilosity 14-16.5 mm. .... **cf. spinolana sp. n.**

30 (25) Tergites I-II (-III) with very fine margins of white hairs. Frons clothed with whitish-yellow hairs.

31 (32) Genae linear. Margins of sternites almost only with black pilosity. Tergites III and following with black hairs ..... **cf. tenuiciliata Alfken**

32 (31) Genae well developed

33 (34) Tibiae III with white scopa ..... **mucida Grib.**

34 (33) Tibiae III with black or ferruginous scopa .... **cf. albosignata Fr.**

35 (10) Smaller species.

36 (71) Posterior margins of the tergites with more or less sharply defined white or yellow fasciae, the disk in front of the fasciae with decumbent black pilosity; there are therefore no pale hairs in front of the fasciae.

37 (52) Metatarsus III exteriorly with black pilosity, or with only single white hairs at the base, above.

38 (39) Tibiae III exteriorly with black pilosity or only with a short stripe of white hairs at the base, above. Tergite II in fresh specimens with greyish-yellow tomentum across the base too so that the tergite appears to have a dark transverse band or line. ..... **fulvodimidiata Dours**

39 (38) Tibiae III not clothed with black hairs. No dark transverse fasciae across middle of any tergite.

40 (41) Tergite V clothed with black hairs only, without white hairs at the sides. Venter with dark hairs only. Antennae dark. Clypeus at fore margin, and a conical median line, pale yellow. Metatarsus II only at the base and the exterior margin with a few white hairs ..... **omissa sp. n.**

41 (40) Tergite V either wholly or at the extreme sides with whitish pilosity.

42 (49) Tergite V only at the sides with white hairs.

43 (44) Smaller species, measuring 8.5-12.5 mm. Wing cells nearly without any pubescence. Very similar to *omissa*, but apart from the different pilosity of tergite V, differing in that the pale colour of the clypeus is more whitish than pale yellow, and the frontal area is dark .... **andresi Fr.**

44 (43) Larger species, measuring 12-15 mm., with distinctly pubescent wing cells, at least near the fore margin of the fore wing.

45 (46) Flagellum of antennae ferruginous below. Head, thorax and tergite I of abdomen without noticeable black hairs among the pale ones..... ..... **cf. farinosa (Kl.)**

46 (45) Antennae dark. Hairs on head, thorax and tergite I of abdomen pale, mixed with black ones.

47 (48) The yellow median stripe of the clypeus conical, narrowed towards base, the yellow fore margin more than one-third as long as the black base. Pilosity of the thorax grey to yellowish grey. Fasciae of the abdomen white. Size larger, on an average ..... **klugi nom. nov.**

48 (47) The yellow median line narrower, parallel-sided; the yellow fore margin at the narrowest space less than one-third as thick as the length of the dark base. Thorax with ferruginous pilosity; the anterior fasciae of the abdomen have a yellowish tinge ..... **quadrifasciata Vill.**

49 (42) Tergite V with white pilosity for all its width, only in the middle of the hind margin with black velvety spot.

50 (51) Fasciae of the tergites very broad. Thorax with yellow-grey pilosity. Clypeus shining in the middle, comparatively sparingly and coarsely punctured. Frontal area only narrowly yellow. Joint 1 of antennae in front (beneath) black or brown, with white pilosity but without white ground-spot ..... **mucorea (Kl.)**

51 (50) Fasciae normal. Thorax with numerous black hairs mixed with the pale hairs. Antennal 1 yellow beneath, flagellum ferruginous beneath. Sides of frons yellow so that the spots of the clypeus are isolated on three sides. Frontal area forming a yellow triangle ..... **punctifrons Walker**

52 (37) Metatarsus III with white pilosity at least in basal half, or with a large white patch at base, or white-haired for all its length; these hairs decumbent or sometimes semi-erect.

53 (56) Face black, or only the labrum reddish.

54 (55) Length 11-12 mm. Face black. Tergites II-IV with white fasciae ..... **blanda Pér.**

55 (54) Length 8.5 mm. Labrum red with black anterior angles ..... **kneuckeri Alfken**

56 (53) Clypeus and labrum at least partly yellow or whitish.

57 (58) The whole tergite V with black pilosity.

a (b) Larger, 13-15 mm. Fasciae of abdomen broad. Black spots of clypeus broadly rounded interiorly, not angular. Antennal 3 as long as the three following joints together ..... **alternans (Kl.)**

b (a) Smaller, 12-13 mm. Fasciae normal. Anterior margin of clypeus only very narrowly pale. Antennal 3 somewhat shorter than the three following joints combined ..... **montivaga Fedt.**

58 (57) Tergite V at least at the sides with white hairs. Smaller species of at most 12 mm. length.

59 (60) Antennal joint 3 long, longer than the three following joints together, more than three times as long as broad. The dark spots of the clypeus angular exteriorly, about their middle. Venter often brownish. Wings also in the discal cells with microsetae. Antennal joint 1 dark ..... **savignyi Lep.**

60 (59) Antennal joint 3 less elongate.

61 (68) Clypeus in front and the median line *broadly* yellow or white. Flagellum usually ferruginous below. Tergite II with adpressed pilosity only.

62 (63) Sides of frons and frontal area yellow, clypeus with two dark spots that are surrounded by yellow. Antennal 1 yellow beneath ..... **cf. punctifrons Wlk.**

63 (62) Sides of frons dark, spots of clypeus fused with the former.

64 (67) Fasciae of the abdomen broad. Antennal 1 sometimes ferruginous below, but not lined with yellow. Flagellum ferruginous below.

65 (66) Metatarsus III exteriorly with large whitish spot of hairs. Fasciae very broad, their fore margin somewhat convex, i.e. broader in the middle. Clypeus and labrum whitish-yellow, the pale median stripe of the former conical. Thorax somewhat narrower, the yellow-grey pilosity mostly mixed with brown or black hairs ..... **latizona Spin.**

66 (65) Metatarsus III black or with only few basal white hairs, exteriorly. Fasciae broad but evenly wide. Clypeus and labrum similar, but yellow, less pale. Thorax with uniformly yellowish-grey pilosity .... **cf. mucorea (Kl.)**

67 (64) Fasciae of abdomen very narrow, whitish. Tergites II-IV also in front of the fasciae with not very dense grey tomentum. Antennae hardly paler beneath. Length 9-9.5 mm..... **cf. alfkenella sp. n.**

68 (61) Clypeus along middle and anterioly only very narrowly white or yellow (2).

69 (70) Frontal area narrowly pale yellow; the pale median line of the clypeus always reaching base. Metatarsus III with white hairs exteriorly for about half its length .....**albigena Lep. ssp. afra nov.**

70 (69) Frontal area black; the pale median line of the clypeus does mostly not reach base or is absent; yellow fore margin fine. Metatarsus III clothed with white or greyish hairs exteriorly for the whole length .... **pipiens Mocs.**

71 (36) Abdomen more or less *evenly* clothed with decumbent grey, yellow-grey or testaceous hairs; the fasciae usually less contrasting from the disks or not contrasting at all. In some cases the tergites (I-) II-III have a narrow transverse black line or band across middle. Scattered raised pale hairs are sometimes visible in profile.

72 (73) Hind tibiae and tarsi exteriorly and interiorly clothed with black hairs, the former exteriorly at base with single white hairs. Clypeus with two dark spots, each being pointed anteriorly within. Thorax with ferruginous pilosity. Middle of tergites I-III with dark transverse line between the pale pilosity of fore and hind margin. Length 10-11 mm .... **fulvodimidiata Dours**

73 (72) Hind tibiae exteriorly with white, grey or yellow to rubiginose pilosity.

74 (81) Metatarsus III exteriorly clothed with black hairs or only up to basal half with white hairs.

75 (78) Metatarsus III with large spot of white hairs at base, its apical half or third with black hairs.

76 (77) Hairs of thorax of two colours, white and blackish. Fasciae very broad, on tergite II broader at middle than laterally. Clypeus and labrum whitish-yellow ..... **cf. latizona Spin.**

(2) cf. *A. montivaga* Fedt.

77 (76) Thorax without black hairs. Tergites densely and evenly clothed with grey hairs, up to the base. Labrum and clypeus, the latter in front and middle, yellow ..... **torensis sp. n.**

78 (75) Metatarsus III exteriorly with black hairs or single white hairs only at base.

79 (80) Tergites fairly evenly clothed with white-grey hairs, on each tergite up to the basal ridge. Veins for the major part dark. Pale parts of ground of face whitish. Legs black on the ground ..... **byssina (Kl.)**

80 (79) Intermediate tergites narrowly black at fore margin of disk. Veins for the major part testaceous. Clypeus in the middle not very densely punctured. Pale parts of ground of face yellowish. Legs brown .... **cf. mucorea (Kl.)**

81 (74) Metatarsus III exteriorly with pale pilosity for all its length.

82 (83) Broadly built species, 10-12 mm. long. Pilosity ferruginous, with intermixed black hairs on vertex, thorax and tergite I. Wings slightly shaded, cells distinctly pubescent. Antennae wholly ferruginous below. Legs brownish on the ground. Scutellum shining in front, sparingly punctured. Clypeus with two large angular black spots ..... **crocea (Kl.)**

83 (82) Smaller species; if 10-11 mm. long, then the pilosity not ferruginous.

84 (85) Length 11 mm., width of head 4.4 mm. Abdomen evenly densely clothed with decumbent grey hairs. Antennal joint 3 about 3 times as long as broad. Clypeus with very dense white pile. Nervulus interstitial .... **galalensis sp. n.**

85 (84) Smaller species of lesser width of head.

86 (109) Dark spot of clypeus large, occupying basal half or more; pale median line narrow or cuneiform or wanting.

87 (98) Nervulus interstitial or very slightly postfurcal.

88 (93) Clypeus with angularly limited black basal spots occupying about basal half. Frontal area narrowly pale. Head at least 3 mm. broad.

89 (90) Abdomen with distinct narrow white fasciae; in perfect specimens also base of tergites with some greyish pilosity, though disks chiefly black. Metatarsus III interiorly with black-brown or black hairs. Flagellum dark or at most brownish below. Face white in front .... **alfkenella sp. n.**

90 (89) Abdomen more extensively clothed with grey hairs, at most tergite II with a narrow blackish fascia across middle. Flagellum ferruginous below. Margins of tergites yellowish transparent. Metatarsus III interiorly with ferruginous to brown hairs.

91 (92) Vertex, thorax and abdomen with uniformly grey to yellowish-grey pilosity. Tergite V medially at hind margin with ferruginous hairs. Metatarsus III interiorly with dark brown hairs. Labrum and fore margin of clypeus yellow ..... **mellina sp. n.**

92 (91) Vertex and thorax with grey and black mixed pilosity. Tergite II with more or less conspicuous dark transverse line. Tergite V with black postero-median cushion of hairs. Metatarsus III interiorly with reddish hairs. Labrum and fore margin of clypeus pale yellow. Somewhat larger species ..... **shagrensis sp. n.**

93 (88) Clypeus with only narrowly pale fore margin, and sometimes fine raised median line. Frontal area mostly dark.

94 (97) Pale hairs of thorax mixed with many black hairs. Pilosity of face less dense. Labrum less strongly transverse.

95 (96) Antennae dark. Labrum, base of mandibles, clypeus in front and a fine median line, whitish-yellow. Pilosity of body uniformly grey. Wing veins dark. Metatarsus III interiorly with black-brown hairs .... **humilis Spin., Pr.**

96 (95) Flagellum slightly reddish towards tip. Labrum, base of mandibles and fore margin of clypeus yellow. Pilosity of thorax grey with slight yellowish tinge. Wing veins testaceous, in basal half. Metatarsus III interiorly with brown hairs ..... **selecta sp. n.**

97 (94) Thorax without, or with single black hairs only. Pilosity of face very densely white. Labrum strongly transverse ..... **cf. tridentella sp. n.**

98 (87) Nervulus distinctly or slightly prefurcal.

99 (100) Antennal joint 3 more than three times as long as broad. Labrum not transverse. Clypeus in the middle triangularly, labrum longitudinally, white, sides brown. Tergites II-V between the decumbent grey pilosity with single raised brown hairs. Metatarsus III interiorly covered with rubiginose hairs. Length 10 mm..... **tarsalis sp. n.**

100 (99) Antennal 3 less elongate.

101 (102) Head distinctly more than 3.5 mm. broad. Pilosity of tergite I moderately long, and raised at base only. Tergites evenly clothed with decumbent grey hairs. White facial pilosity not very dense ..... **deceptrix sp. n.**

102 (101) Head narrower, width at most 3.5 mm. Very small species.

103 (104) Antennae almost wholly dark or only tip brownish below. Clypeus without pale median line, fore margin only narrowly whitish, frontal area dark. Tergite II with a few raised pale hairs besides the decumbent hairs. Fasciae of tergites indicated ..... **tridentella sp. n.**

104 (103) Flagellum ferruginous below. Clypeus with more or less narrow pale median line connected with pale fore margin which is broader. Frontal area sometimes pale. Fasciae not pronounced.

105 (106) Sternites IV and V with slightjy raised *black* pilosity, only the hind margins with very poor white fringe. Antennals 1-4 dark. Metatarsus III interiorly with brown hairs. Tergite II with few pale raised hairs between the dense decumbent white pilosity ..... **candidella sp. n.**

106 (105) Sternites on the disks without black, but with slightly raised ferruginous or brown, pilosity; margins with a few white fringe hairs.

107 (108) Metatarsus III interiorly clothed with dark brown or black hairs. Abdomen with very dense white-grey pilosity, tergite II without any raised hairs. Antennal joints 1, 2 and base of 3 black, 3 abruptly ferruginous at the distal widening, rest of flagellum ferruginous below. Face with dense white pile. Nervulus distinctly prefurcal ..... **nivosella sp. n.**

108 (107) Metatarsus III interiorly with ferruginous or rubiginose hairs. Pilosity of the tergites grey. Face less densely pilose so that the dark ground of the clypeus becomes visible. Tergites II-III with a few raised pale hairs, visible in profile. Antennal joints 1-3 dark, 4-12 ferruginous below. Nervulus only very slightly prefurcal. ..... **tenella (Kl.)**

109 (86) Dark spots of clypeus *small*, occupying less than half of the length of the clypeus which is medially broadly pale yellow or yellow to base, or almost wholly yellow.

110 (111) Head somewhat more than 3.5 mm. broad. Nervulus interstitial. Tergites II (-III) with or without dark transverse median line. Length 9 mm..... ..... **lutulenta (Kl.)**

111 (110) Width of head less than 3.5 mm.

112 (115) Nervulus very slightly prefurcal. Pale hairs of thorax mostly mixed with black hairs. Metatarsus III interiorly clothed with black-brown to black hairs. Calcaria yellow with dark margins or dark.

113 (114) Tergite V with dark brown or black cushion of hairs in the middle of hind margin. Dark central transverse fascia on tergites I-III usually conspicuous ..... **concinna (Kl.)**

114 (113) Tergite V with ferruginous hairs in the middle of the hind margin. Dark transverse lines inconspicuous, only indicated on tergites I and II.... ..... **concinna hegasica nov.**

115 (112) Nervulus interstitial. Metatarsus III interiorly with pale brown ferruginous or brown pilosity. Calcaria of tibiae II and III pale yellow. Thorax without intermixed black hairs. Tergite V in the middle of its hind margin with testaceous to brown hairs ..... **fayoumensis sp. n.**

116 (1) Abdomen either with fasciae of pale, more or less decumbent hairs, but the tergites on the disks with distinctly, mostly vertically, *raised* hairs; or tergites with raised hairs and without fasciae. The raised hairs may be plumose or almost simple.

117 (158) Larger species of at least 13.5 mm. in length; if smaller, then thorax with ferruginous pilosity.

118 (119) At least middle and hind tibiae and tarsi reddish brown or ferruginous on the ground ..... **cf.** 15

119 (118) Legs black on the ground.

120 (131) Pilosity of thorax yellow, ferruginous or rubiginose, without black hairs.

121 (128) At least tergite II with a fine white fascia at its apical margin.

122 (125) Genae linear or practically wanting.

123 (124) Tergites II-IV with conspicuous snow-white fascia. Hind tibiae exteriorly with black or dark brown hairs, and a longish triangular spot of white hairs. Metatarsus III with black hairs ..... **oraniensis Lep.**

124 (123) Tergites (I-) II with very narrow margin of white hairs. Legs with black pilosity ..... **cf. tenuiciliata Alfken**

125 (122) Genae well developed.

126 (127) Hind tibiae clothed with black hairs, or only tips of tibiae and metatarsi with a few white hairs or with reddish hairs towards lower margin. Tergites I-II (-III) with very fine fascia of white hairs .. **albosignata Fr.**

127 (126) Hind tibiae exteriorly clothed with white hairs. Tergites II-III with very fine fascia of white hairs ..... **mucida Grib.**

128 (121) Tergites without white marginal fasciae or only at the sides with some white hairs. Large species : 17-20 mm.

129 (130) Pilosity of head predominantly black or brownish .. **alfierii Alfken**

130 (129) Pilosity of head for the major part pale. Hairs of tibiae more distinctly raised..... **hispanica F.**

131 (120) Thorax above clothed with white-grey or yellow-grey to brown-grey hairs, in the latter case often mixed with black hairs.

132 (139) The white fasciae of the tergites broadly interrupted in the middle.

133 (134) Large species (16-17 mm.) with distinctly plumose hairs on tergite II, pale transparent margins of the tergites and with brownish or testaceous markings on the clypeus ..... **cf. aegyptiaca DT. & Fr.**

134 (133) Not the above characters combined.

135 (136) Pilosity of head and hind tibiae entirely black. Slenderer species, length 12.4-14 mm..... **cf. facialis sp. n.**

136 (135) Head predominantly with pale pilosity.

137 (138) Hind tibiae exteriorly clothed with white hairs. Fasciae conspicuous, white, but always interrupted in the middle. Length 11-13 mm. ..... **atriceps Pér.**

138 (137) Hind tibiae with black pilosity. Broad species .....**cf. albosignata Fr.**

139 (132) Fasciae of the abdomen not interrupted, or entirely absent.

140 (141) Pilosity of hind tibiae and head black ..... **facialis sp. n.**

141 (140) Pilosity of hind tibiae wholly whitish, grey, yellow or ferruginous.

142 (155) Pilosity of hind tibiae golden-yellow, ferruginous or rubiginose.

143 (146) Tergites II-IV without black hairs between the long raised white-grey pilosity.

144 (145) White fasciae on tergites (I-) II-IV conspicuous. Nervulus interstitial or indistinctly postfurcal ..... **speciosa Fr.**

145 (144) Abdomen without noticeable fasciae, with greyish villosity. Nervulus indistinctly prefurcal ..... **lanata (Kl.)**

146 (143) At least the tergites III-IV either wholly clothed with black hairs, or with grey hairs which are mixed with some black hairs.

147 (148) Smaller species of 13-14 mm. length, and transparent pale margins of the tergites. Pilosity grey, on tergites III and IV not predominantly black, the grey hairs plumose. Interior face of tibiae and metatarsus III with black pilosity ..... **senescens Lep.**

148 (147) Tergites III and IV with predominantly or wholly black pilosity. Length 14.5-18 mm.

149 (152) At least the tergites II and III with conspicuous fasciae of almost decumbent or slightly raised white hairs.

150 (151) Clypeus and labrum mostly with brown or yellow markings. Raised hairs of tergite II distinctly plumose. Legs with rubiginose hairs. Length 16-17 mm. ..... **aegyptiaca DT. & Fr.**

151 (150) Head black on the ground. Raised hairs on tergite II not distinctly plumose. Hind tibiae and metatarsi III interiorly clothed with black, exteriorly with ferruginous hairs.

a (b) Tergites with slight bronze lustre, puncturation denser. Sternites with fringes of ferruginous hairs. Tergites clothed with long grey hairs, mixed with black hairs. Length 17-18 mm. ..... **disparilis Fr.**

b (a) Tergites black on the ground, puncturation less dense, II-III clothed with black hairs, towards the hind margin with white hairs. Fasciae more conspicuous. Length 15.5-16.5 mm. ..... **dispar Lep.**

152 (149) Conspicuous fasciae absent. Tergites I and II clothed with grey, the following tergites almost only with black hairs, some pale hairs at most at the sides of the tergites.

153 (154) Mesosternum for the major part, fore and mid legs, hind tibiae within and both sides of metatarsus III clothed with black hairs; hind tibiae exteriorly with rubiginose hairs ..... **cinereiceps Alfken**

154 (153) Mesosternum clothed with grey, or in the middle somewhat with yellowish, hairs. At least the hind legs everywhere with ferruginous hairs. Pilosity of thorax and tergites short ..... **spinolana sp. n.**

155 (142) Hind tibiae exteriorly and metatarsus III predominantly with white or grey hairs (3).

156 (157) Ground of face partly pale yellow. Tergites I-III with white fasciae, and in addition with whitish or greyish decumbent and semi-erect pilosity to base. Tergites IV and V with black, only at the sides with white, raised hairs ..... **atricilla ssp. aegyptorum nov.**

157 (156) Face wholly dark. Tergites with raised grey, but without decumbent white-grey, pilosity. Fasciae present on tergites I-IV. Tergite V at the sides with some longer white hairs ..... **niveiventris Fr.**

158 (117) Smaller species not exceeding a length of 13 mm.

159 (160) Clypeus yellow or white with two black spots, and with median line or at least fore margin pale ..... **cf.** 86-115

160 (159) Clypeus black.

161 (162) The pure-white fasciae of the abdomen broadly interrupted. Hind tibiae exteriorly with white, metatarsus with black, hairs. General colour black ..... **cf. atriceps Pér.**

162 (161) Fasciae not interrupted, or absent. General colour grey.

163 (166) Antennal joint 3 about three times as long as 4, or at most as long as the three following joints combined. Fasciae narrow. Cells of wing close to fore margin of it distinctly pubescent. Length 8-9.5 mm. (4).

164 (165) Tergites I-IV of abdomen clothed with grey hairs only, V with some black hairs too ..... **moricei Fr.**

165 (164) Tergites II-V of abdomen with some black hairs mixed with the pale ones..... **moricei nigripilis nov.**

166 (163) Antennal 3 longer and slenderer, distinctly more than three times as long as 4, and at least above longer than the three following joints together; larger, on an average.

167 (168) Sternites II-IV with white or greyish hairs only, without brown or black hairs between them. Wing cells practically bare, only in cell r 1 with some microsetae ..... **wegelini Fr.**

168 (167) Sternites at least in the middle of the disks with brown or black hairs between the pale hairs. Thorax and tergites III-IV with white and dark hairs mixed, V with black hairs.

169 (172) Tergites III-V in front of the fasciae mainly with black hairs. At least the sternites IV-V with many black hairs.

170 (171) Clypeus densely and somewhat rugosely punctured, without median

(3) A grey scopa stuffed with yellow or brownish pollen should not be mistaken with a yellow or brown scopa.

(4) *Anthophora guigliae* Dusmet (*Ann. Mus. Genova*, LIII, p. 314; 1933) may also belong in this section. The rich ferruginous pilosity of tergites V and VI would, as to my opinion, distinguish this species from all those of the *ambigua*-group, if it actually belongs in this group. (Jarabub).

carina. Abdominal fasciae composed of somewhat raised hairs .... **zanoni var. borgensis nov.**

171 (170) Clypeus like above, but in front with narrow median carina. Fasciae of abdomen snow-white, denser, more decumbent ..... **desertorum sp. n.**

172 (169) Tergites in front of the fasciae predominantly with white or grey hairs. Sternites with yellowish or medially with brown hairs.

173 (176) Mesonotum with few black hairs between the pale hairs. Hairs of tergites raised and mixed with less black hairs. Pilosity with a slight yellowish tinge.

174 (175) Clypeus coarsely punctured, and at least in front with a small carina. Antennal 3 as long as the three following joints together..... ..... **priesneri Alfken**

175 (174) Clypeus finely and densely punctured, shining. Antennal 3 somewhat longer than the three following joints together ..... **extricata sp. n.**

176 (173) Mesonotum with many black hairs among the grey hairs. Grey pilosity of the tergites less raised and mixed with many black hairs, without yellow tinge..... **cf. crassipes Lep.**

DESCRIPTIONS OF THE EGYPTIAN SPECIES

Group I (fulvitarsis)

Anthophora aegyptiaca Dalla Torre et Friese

1812. Unnamed, Savigny, Descr. d'Egypte, pl. I, fig. 3 (male).
1845. *Megilla scopipes* Klug., Symb. phys., pl. 49, fig. 1 (nec *scopipes* Spin.).
1871. *Anthophora senilis* Walker, List Hym. Egypt, p. 55.
1895. *Anthophora aegyptiaca* Dalla Torre et Friese, *Entom. Nachrichten*, XXI, p. 60.
1897. *Podalirius aegyptiacus* Friese, Bienen Europas III, p. 174.
1916. *Anthophora fulvitarsis* Storey, Min. Agric., Tech. Bull. 5, p. 18; Cairo.
1926. *Anthophora aegyptiaca* Alfken, *Senckenbergiana*, VIII, p. 101, 122.

Male : Length 15-17 mm. Colour of the ground black, the whole face including frontal area, base of mandibles, and 1st antennal joint beneath, yellow. Pilosity appearing for the major part grey, with yellowish tinge like being shortly cut, and being longer and darker only at the posterior tergites; posterior margins of tergites only narrowly pale transparent. Frons clothed with white, vertex profusely covered with black hairs. Thorax and tergites I and II with raised, the latter two with raised and distinctly plumose, hairs, tergites III to VII with raised black hairs. Whitish posteromarginal bands are conspicuous on tergites (I-) II-IV, but mostly interrupted on IV in the middle. Mid legs with anterior black fan of the metatarsus and longer, scarcer, posterior pilosity; joint 5 of tarsi II with distinct hair-brush. Hind tibiae at the margins with dirtily brownish or yellowish pilosity. Posterior metatarsus somewhat *curved*, convex interiorly, concave exterio ly. Calcaria yellow,

narrowly margined with black. Head below with white, chest with yellowish pilosity. Tegulae yellowish-brown.

Genae well developed. Clypeus strongly protruding, shining, very finely punctured. Antennal joint 3 about 3.5 times as long as broad, somewhat longer than the three following joints combined. Wings slightly shaded with grey, with cell r 1 distinctly pubescent. Nervulus (vein Cutl) interstitial. Tergite VII with two comparatively long, ferruginous teeth that are comparatively narrowly separated from each other.

FEMALE : Length 16-17 mm. Black, face too, but clypeus mostly with yellowish spots, or wholly dark brown with yellowish-brown median stripe, or small paler spots or with anchor-shaped design. Labrum dark, mostly yellowish at the basal margin. Pilosity about as in the male. Tibiae and tarsi clothed with rubiginose hairs, margins of the sternites laterally with whitish, medially with ferruginous hairs. Tegulae ferruginous.

HABITAT : A common hibernal species that may be collected, though, from August to April in Middle and Upper Egypt.

A. aegyptiaca can hardly be confused with any other Egyptian species, systematically coming closest to *A. fulvitarsis* Brullé. It is heavier than the species of the *scopipes*-group, and differs further from *flabellana*, the only one of the latter having yellow clypeus, by the conspicuous teeth of tergit VII of the male, the curved metatarsi III and the longer antennal joint 3; the females differ from those of the *scopipes*-subsection by the larger size, the dark-haired tergite V, the dark ground-colour of the tibiae and metatarsi and by the pilosity of the thorax which is more strongly mixed with black hairs, in *aegyptiaca*. The specimens in the collection of the Ministry of Agriculture were originally identified with *A. nasuta* Lep., but already in 1926 corrected by ALFKEN in *aegyptiaca*.

Anthophora senescens Lep.

1841. *Anthophora senescens* Lepeletier, Hist. nat. Ins. Hym., II, p. 71 (male and female).
1897. *Podalirius senescens* Friese, Bienen Europas, III, p. 179.
1916. *Anthophora retusa* Storey (nec L.), Min. Agric., Techn. Bull. 5, p. 18; Cairo.
1926. *Anthophora senescens* Alfken, *Senckenbergiana*, VIII, p. 101.

MALE : Length 11-13 mm. Ground colour black, apical margins of the abdominal segments pale, transparent. Antennal joint 1 beneath, clypeus, sides of frons, frontal area transversely and labrum ivory yellow. Mandibles and flagellum black. Pilosity appearing, as a whole, grey, since black and white hairs are mixed almost everywhere. Hairs of frontal sides surpassing clypeus. Head and thorax beneath with long white hairs. Pilosity of the abdominal tergites long and raised, the paler hairs of the tergites are distinctly plumose; at the little conspicuous fasciae the hairs are whitish. Metatarsus II exteriorly with chiefly black pilosity, and with fan at the anterior edge. Tarsal joints 2-4 yellowish, joint 5 dark, possessing a distinct

brush on tarsi II. Pilosity of the hind tibiae black, at the posterior edge and tip whitish; metatarsus III with black, only at the extreme apical margin with whitish, hairs. Tergites very finely and densely punctured. Tegulae dark with pale margin. Wings only in the cells close to fore margin sparingly pubescent. Nervulus interstitial. Antennal 3 abruptly thickened at the apex, about three times as long as broad. Tergite VII with two widely separated fine ferruginous teeth that are partly covered by hairs.

FEMALE : Length 13-14 mm. Black. Clypeus densely punctured, without median carina. Antennal 3 more than three times as long as broad, somewhat longer than the three following joints together. Pilosity about as in the male, but the hind tibiae exteriorly with yellowish or ferruginous pilosity, and the metatarsus III at base profusely set with ferruginous hairs, apex and posterior margin with black hairs. Tarsi dark, calcaria brownish with black margins. Posteromarginal fasciae of the abdomen somewhat more conspicuous than in the male, i.e. on segments I-IV. Tergite VII clothed with black hairs in the middle.

HABITAT : Common from the Delta to Fayoum, and also on the northern belt (Alexandria, Mariout).

Group II (mucida)

Anthophora atricilla Evers. ssp. aegyptorum nov.

1812. Unnamed, Savigny, Descr. d'Egypte, pl. I, fig. 9 (female).
1897. cf. *Anthophora atricilla* Eversmann, Friese, Bienen Europas, III, p. 165, fig. (references).
1916. *Anthophora atricillus* Storey, Min. Agric., Techn. Bull. 5, p. 18.
1924. *Anthophora stschurowskyi* Gribodo, *Boll. Mus. Zool. Torino*, XXXIX, N.S. XVI, p. 7.

MALE : 16-18 mm. Black, face pale yellow with dark spot at the clypeo-frontal suture, mandibles with yellow basal spot, sides of the frons and frontal area narrowly (not triangularly) yellow, antennal joint 1 yellow beneath. Face with fine white and raised, vertex with sightly yellowish, thorax with pale yellow, pilosity and only few dark hairs intermixed. Tergite 1 with pale yellowish raised pilosity, without dark hairs, tergite II with shorter raised pilosity, the ground visible everywhere; tergites I-III with narrow white marginal fasciae, and in front of these very shortly, on the posterior segments somewhat longer, raised black pilose. Sterna of thorax clothed with white, sternites of the abdomen with longer and denser such hairs. Metatarsus III clothed with dark, and only a few white, hairs, terminal margin white-haired. Tibiae with scarce whitish pilosity but short black ground-clothing, margin shortly yellowish-white pilose, at the lower margins with long white hairs. Metatarsus II slender, without fan. Joints 5 of the fore *and* middle tarsi, with a conspicuous brush of black hairs, the one on the middle tarsi larger. The median joints of the tarsi reddish beneath their pilosity.

Clypeus somewhat protruding, densely punctured. Labrum as long as broad or slightly longer. Antennal 3 slender, somewhat thickened at the apex but not abruptly so, slightly more than 3 times as long as broad and longer than the three

following joints together. Tegulae yellowish with dark center. wings slightly shaded, having only cell r 1 distinctly pubescent; nervulus interstitial. Tergite VII in the middle of the apex produced into a laterally somewhat wavy, posteriorly truncate, plate which is set with white hairs at the sides.

FEMALE : 16-17.5 mm. Black, clypeus in front and labrum yellow, the latter with two lateral dark basal dots, the clypeus at base and the sides of the face dark, the former with fore margin and median band reaching base, yellow, frontal area mostly wholly black. Mandibles black. Pilosity as in the female, yellowish on the vertex but more whitish than yellow on the thorax where it is mixed on the disk with black hairs, and the base of the scutellum is transversely set with black hairs. Tergite I clothed with raised whitish, tergite II with short raised whitish, hairs, tergites I-III, besides, each with a white fascia that is somewhat ill-defined in front; the tergites are not only at the margin but also at the base clothed with partly raised, partly adpressed pale hairs; tergites IV-VI with short raised black pilosity, the lateral margins with long white hairs. Thoracic sterna with greyish-white hairs, abdominal sternites with lateral white fringe being shorter and less dense than in the male. Tibiae exteriorly clothed with white hairs, metatarsus III with large, white, basal hair-spot. Tarsi beneath their clothing black.

Clypeus densely punctured, slightly keeled in the middle, narrowly smooth. Antennal joint 3 long, about four times as long as broad, and about as long as the four following joints combined. Wings as in the male.

HABITAT : This species is not rare at the northern coast (Mamoura, Montaza, Borg-el Arab, Ikingi (II-VI), and was taken in great numbers at Borg by the collectors of the Cairo University.

The male of this species was unknown to ALFKEN, the female he considered to be *cinerascens* Lep. However, our species cannot be identified with *cinerascens*, since the latter possesses a rather small, nearly rectangular black clypeus spot, and the lower margin of the 5th tergite has ferruginous hairs; moreover, the legs have a ferruginous, not black, ground-colour, in *cinerascens*. The species occurs in Nubia, while our species is decidedly Mediterranean. As I could get convinced after examination of specimens in the Vienna Museum, our form is very similar to *atricilla* Ev. which belongs to the few species having a tarsal brush on the middle *and* fore tarsi of the male. The specimens concerned (2 females, Araxes valley, det. FRIESE) have the posterior metatarsus wholly white exteriorly, in the Egyptian specimens the white hairs are not developed all along the metatarsus; the abdominal tergites II/III have a very dense yellowish-white decumbent pilosity, in the Egyptian specimens the hairs are much less dense, and are white so that in these the fasciae become very conspicuous, while in *atricilla* this is not the case. The pilosity of *atricilla* is more yellow on the thorax, too. Presumably, the Egyptian form can be considered to be a race of *atricilla*. The female specimens of the collection of the Ministry of Agriculture were under the name of *A. robusta niveiventris* Fr., though identified neither by FRIESE nor ALFKEN, but perhaps by STOREY. However, *A. niveiventris* has proved

to be a quite different insect, as can be seen from the description given on a later page. STOREY has *A. atricilla* in his list, thus he must have seen the male, though the above collection does not contain any males from that time.

Anthophora pretiosa Friese

1919. *Anthophora fulvitarsis* var. *pretiosa* Friese, *Deutsche Ent. Zeitschr.*, p. 279.

MALE : Length 15.5-16 mm. Black, antennal joint 1 beneath and the whole face inclusive of the frontal area, ivory-yellow, fore margin of clypeus with a fine black line; mandibles with a yellow spot at the base towards the upper margin. Pilosity of the frons yellow-white, of the vertex ferruginous, only at the upper angles of the eyes with a few black hairs. Thorax and abdominal tergite I clothed with raised ferruginous to rust-coloured hairs, tergite II in the two basal thirds with pale yellow hairs, in the posterior third these are mixed with some black hairs. The middle of the thorax distinctly mixed with black hairs. Tergites III-V with black hairs, hind margins of the tergites II-IV with loose, not quite decumbent, pilosity. Under side of head with grey-white, of thorax with more yellowish hairs, femora with pale yellow or whitish-yellow hairs. Tibiae exteriorly clothed with black hairs, but the margins longer, raised, pale yellow hairs. The fore and hind legs are provided on their 5th joint with a roundish, conspicuous brush. Calcaria ferruginous or with fine black margins.

Clypeus strongly protruding, dull, very finely and indistinctly punctured, finely transversely rugose towards fore margin; labrum nearly square, smooth and shining. Interior orbits convex. Antennal joint 3 abruptly thickened at the apex, about as long as the four following joints combined. Tergites strongly shining, very finely punctured over the whole surface. Metatarsi long and slender, flattened. Wings little shaded, pubescence noticeable only at the fore margin of the anterior cells, more distinctly in cell r 1. Nervulus interstitial. Tergite VII dark reddish, truncate apically, without protruding angles, finely and densely punctured, in the middle with very fine sulcus.

FEMALE unknown.

HABITAT : 1 male, Ikingi 11. ii. 1912, leg. A. ANDRES.

The description is given after the holotype of FRIESE, deposited in the collection of the Berlin Museum.

Among all Egyptian species a distinct lateral brush on the apical joint of the *fore* tarsi is only developed in this species and in *atricilla aegyptorum*. The latter species has decumbent fasciae on the tergites (I-) II-III, and is clothed with yellowish, not ferruginous, hairs on the thorax and the 1st abdominal tergite, and the pilosity of the legs is much more adpressed. The formation of the VIIth tergite clearly shows that this species does not belong near *fulvitarsis*.

Anthophora dispar Lep.

1841. *Anthophora dispar* Lepeletier, Hist. Nat. Ins. Hym., II, p. 56 (male and female).
1897. *Podalirius dispar* Friese, Bienen Europas, III, p. 202, fig. (further references).
1916. *Anthophora dispar* Storey, Min. Agric., Techn. Bull. 5, p. 18, Cairo.
1926. *Anthophora dispar* Alfken, *Senckenbergiana*, VIII, p. 123.

MALE : Length 13-14.5 mm. (5) Black, joint 1 of the antennae beneath and face yellow, i.e. labrum, clypeus, a narrow transverse frontal area and V-shaped spots at the sides of the frons (orbits); the yellow clypeus is therefore separated by a basally narrower, distally broader, black band or line; labrum with 2 dark basal spots. Mandibles dark. Tarsal joints 2-4 and base of 5 more or less dark testaceous. Calcaria yellow to brown, margined dark. Face with raised white, on the vertex more yellowish, pilosity which is mixed at the orbits and the vertex with black hairs. Thorax, 1st and the basal two-thirds of the 2nd tergite with raised yellow to yellow-grey hairs which are on the dorsum of the thorax well mixed with many black hairs; apex of the 2nd and the whole 3rd to 6th tergites with raised black hairs; the margins of the tergites 2-4 with loose white hairs at the sides, which become denser on the 5th and 6th tergites. Under side with raised white hairs. Legs with decumbent and raised black, and raised white hairs between, the latter especially at the hind margins of the tibiae and metatarsi, but also on the intermediate tarsal joints. Metatarsus II with roundish fan of dark hairs exteriorly, 5th joint of tarsi II with a round black brush.

Clypeus protruding, labrum very moderately transverse, both moderately densely punctured, the latter coarsely and rugosely so. Antennal joint 3 abruptly thickened at the apex, about four times as long as broad. Tegulae brown, margins testaceous. Wings somewhat shaded, the cells m1, r1 and sc pubescent near fore margin. Nervulus interstitial. Posterior metatarsus at its exterior face *swollen and shining*. Tergite VII with broad apical plate that is truncate and slightly emarginated apically, the angles are nearly rectangular and not distinctly dentate.

FEMALE : 15.5-16.5. mm. Black. Sides of frons with whitish hairs, vertex and orbits strongly mixed with black hairs; thorax with grey pile, since they are much mixed with black hairs; tergite I clothed only with white hairs, tergite II with white hairs but much mixed with black hairs across the middle, tergites III and IV with black hairs in basal half (or more), then with such raised white hairs; tergites (I-) II-IV, besides, with *white* marginal bands of long, partly horizontal hairs, V at the sides with white, in the middle with black hairs, and a few brown hairs. Sternites at the sides with white, in the middle with dark reddish, fringe hairs. Under side of thorax with dirty-white hairs. Tibiae and metatarsi exteriorly with *rubiginose* hairs.

Clypeus rather coarsely punctured, a fine smooth median line is noticeable. Antennal joint 3 more than four times as long as broad, as long as the four following joints together. Wings as in the male.

(5) According to FRIESE the European males have a length of 16-17.5 mm.

HABITAT : Common in the Delta, from December to March. Localities : Toukh, Nawa, Cairo, Heliopolis, Giza, Meadi, Esbeth-el-Nakhl.

Although the abdominal bands of the typical *A. dispar* are less distinctly white and narrower, the above described form is identical with specimens from Algeria. ALFKEN identified specimens (from Giza, coll. ALFIERI) with *A. dispar* Lep. However, some specimens (from Toukh, coll. PRIESNER) he identified later with *A. dispar* v. *speciosa* Friese which is quite another form, described below. ALFKEN's statement (*Senckenbergiana*, VIII, p. 123, 1926) that *A. speciosa* Friese (*D. E. Zeitschr.*, p. 279, 1919) is the Egyptian form or race of *A. dispar* Lep. can therefore not be correct. *A. speciosa* must be either a separate species or a littoral race of *A. dispar*. Both are Egyptian, the former found mainly in the coastal regions, the latter hitherto only in Middle Egypt.

Anthophora speciosa Friese

1919. *Anthophora dispar* v. *speciosa* Friese, *Deutsche Ent. Zeitschr.*, p. 279 (male).
1922. *Anthophora niveohirta* Friese, *Konowia*, I, p. 60 (female).
1926. *Anthophora dispar* v. *speciosa* Alfken, *Senckenbergiana*, VIII, pp. 101, 123 (male and female).

MALE : Original description (from German) : Like *A. dispar* but thorax and segment I with long and nearly ferruginous, segment II with white, segments III-IV with short black, pilosity, segments V-VII with long white pilosity. Legs with long white hairs. Length 15 mm., width 6 mm. In the coloration very similar to *A. pretiosa* but apex of abdomen with whitish pilosity, and easily recognizeable as belonging to *A. dispar* by the swollen metatarsus. 2 males, Ikingi, ii. 1912, ANDRES leg.

ALFKEN says that the thorax and the 1st tergite of the abdomen are in fresh specimens clothed with ferruginous pilosity that is sparingly mixed with black hairs. The 2nd tergite is on the whole disk covered with pale hairs the 3rd and 4th tergites are set with black, at the hind margin with long bristly white, hairs. The male remained unknown to me.

FEMALE : 16-16.5 mm. Black, face clothed with white, on the labrum somewhat yellowish, on the vertex, especially above at the orbits, with white and black hairs. Thorax covered with grey hairs, the white being mixed with few black hairs. Abdomen with raised white hairs, and loose posteromarginal fasciae of white hairs on tergites (I-) II-IV, about as in *dispar*; there are no or only single black hairs on tergite IV, the tergites look unicolorous throughout, only tergite V is medially set with black, but with white hairs at the sides. The hind margins of the sternites are fringed at the sides with white, in the middle with ferruginous, hairs. Hind tibiae and metatarsus III exteriorly with golden yellow to ferruginous, interiorly with black, pilosity. Tegulae brown, margins reddish.

Clypeus densely and coarsely punctured, with smooth median line, as in *A. dispar*. Antennal 3 very long, abruptly widened at tip, nearly five times as long as

thick and nearly as long as the five following joints combined. Genae well developed. Nervulus interstitial or scarcely postfurcal. Wings only slightly shaded, veins dark, pubescence only visible at the fore margins of the anterior cells.

HABITAT : Northern coast (Ikingi, Borg el Arab, Wardân) and Mansuriah (February - April).

This form is distinguished in both sexes by the coloration; in the male the thorax shows ferruginous, instead of dirty white or testaceous, hairs, tergite II bears white hairs all over the disk (in *dispar* only at the base), III and IV are more extensively white at the hind margins (in *dispar* either black or with few white hairs). From *A. lanata* Kl. the female differs by the conspicuous, though loose, white fasciae of the abdomen and the interstitial nervulus. — I saw FRIESE's type specimen of *A. niveohirta*.

Anthophora disparilis Friese

1922. *Anthophora disparilis* Friese, Konowia, I, p. 60 (female).
1926. *Anthophora disparilis* Alfken, *Senckenbergiana*, VIII, pp. 101, 124 (male and female).

FRIESE's original description runs as follows (from German) : "Allied to *dispar* but larger, abdomen with yet longer pilosity, scopa yellowish. Female black, with very long grey-yellowish pilosity, head and thorax punctured, somewhat shining, clypeus-labrum somewhat more coarsely punctured, genae conspicuous and red, longer than in *dispar*, antennae black, flagellar joint 2 very long, equalling the four following joints combined. Abdomen with slight bronze sheen, finely and partly densely punctured, shining, with very long grey hairs, segments I-IV with only single black hairs intermixed, V in the middle with black, laterally with red, VI with ferruginous hairs, anal plate narrow, blackbrown and margined. Ventral segments punctured, with long yellow fringe. Legs black with yellowish pilosity, tibiae I in front with black hairs, scopa with yellowish pilosity, penicillus black-brown, tarsi I and III interiorly with red pilosity, calcar yellowish. Wings shaded, veins black-brown, tegulae black, with long black hairs. — Length 17-18 mm., width 6 mm. — Palestine".

I saw a female specimen of this species from FRIESE's collection (Mus. Berlin) labelled type (though from Syria, not Palestine) that fully agrees with the above description, showing the rather long and bristly pilosity of the abdomen, in which the grey hairs of the tergites from II onwards are profusely mixed with black hairs, and tergite V is laterally set with ferruginous to brown hairs, and exteriorly, like the hind tibiae, clothed with dirty yellow-grey hairs; the puncturation of the tergites is denser than in *dispar*, and they show, especially tergite II, a slight metallic bronze lustre; the sternites have a fringe of ferruginous hairs, the clypeus is in the middle narrowly smooth.

So far I did not come across this species, though ALFKEN records it from Egypt (no locality given), saying that the female (length 17.5 mm.) is characterized

by its broad, compact abdomen, and the pilosity of it which is rather even, long, white-grey and has *no black hairs at the base of tergites III and IV*. The white bands at the apices of tergites I-IV are narrower than in *A. speciosa* and are less conspicuous among the white-grey hairs; tergite V shows dense black pilosity. The plate of tergite VI is shorter and broader than in *A. speciosa*, the fine transverse sculpture is less distinct and there is a very fine and dense puncturation visible. The labrum has a dense ferruginous pile (in *A. speciosa* less densely greyish). ALFKEN also briefly described a male that he tentatively put to this species. It is structurally identical with *A. dispar* and *A. speciosa*, but has vertex, thorax and abdominal segment I clothed with ferruginous, the remaining tergites evenly clothed with grey-white, hairs, only on tergite V there are black hairs among the others. Length 16.5 mm.

ALFKEN's statement that the Egyptian female specimen he examined had no black hairs on the tergites III and IV does not agree with the type specimen FRIESE's I saw; ALFKEN's specimen may be a variety or even another species.

Anthophora niveiventris Friese

1916. *Anthophora agama* Storey (nec Rad.), Min. Agric., Techn. Bull. 5, p. 17.
1919. *Anthophora robusta* var. *niveiventris* Friese, *Deutsche Ent. Zeitschr.*, p. 279.

FEMALE : 16-17 mm. Black. Face and temples with moderately long white, vertex on the hind margin transversely with wholly black, pilosity. Thorax covered with grey hairs, i.e. white and black hairs mixed, at the base of the scutellum with a transverse row of black hairs. Propodeum clothed with white hairs. Abdomen covered with raised hairs which are on the tergite I grey-white, on II white and black mixed, on III and the following tergites increasingly and predominantly black; the tergites possess complete, sharply defined apical fasciae of white hairs, on tergite V the pilosity is white on the sides, black or blackish-brown in the broader middle. Head and thorax are clothed beneath with grey-white hairs. Fore legs with black to grey pilosity, apex of tibiae with small pale hair-spot, middle and hind tibiae exteriorly with silvery whitish-grey pilosity, the metatarsus II exteriorly shining, with decumbent black pilosity and with a few white hairs between, metatarsus III exteriorly for the major part with silvery whitish-grey, interiorly with black (along the middle somewhat brownish), pilosity. Tegulae dark brown, margins paler.

Clypeus rugosely punctured, with median line somewhat smoothened. Antennal joint 3 very long and fine, abruptly thickened at the apex, four to five times as long as broad, longer than the four following joints together, nearly as long as the 5 following joints. Wings slightly shaded, in the cells of the fore margin only anteriorly slightly pubescent, distinctly so only in cell r 1. Veins black. Nervulus interstitial.

Male unknown.

HABITAT : Mariout, Matrouh, in February and March.

Among the fasciated species having raised pilosity of the abdomen and a white scopa can this large one only be compared with *atricilla aegyptorum*; but in this species the pilosity of the tergites II and III is decumbent and pruinose, and also developed somewhat at the base of the 2nd tergite, the tergite IV has no white band in the middle of its margin, and the labrum and clypeus have a pale ground-colour. *A. senescens* is much smaller, has much less sharply defined fasciae of the abdomen, shorter antennal 3, a.s.o.

In the collection of the Ministry of Agriculture this species bore the name *agama* Rad., a species differing not only by the yellowish pilosity of the thorax and tergite II, but especially by the yellow labrum, and partly yellow clypeus and mandibles.

I was able to examine one of FRIESE's type specimens, and thus to give a full description from this and a few other specimens of the local collections.

Anthophora mucida Gribodo

1873. *Anthophora mucida* Gribodo, *Bull. soc. ent. Ital.*, V, p. 80 (female).
1897. *Podalirius mucidus* Friese, Bienen Europas, III, p. 230 (male and female; fig.).

MALE : Length, 15-16 mm. Black, antennal joint 1 beneath, labrum and clypeus *yellow*, frontal area and sides of frons narrowly yellow, clypeus with two black spots that are obtusely angled interiorly. Mandibles black. Joint 5 of middle tarsi with a slight brush, metatarsi slender. Tarsal joints 2-4 and base of 5 yellow. The fasciae on tergites II and III weaker than in the female, otherwise the pilosity as in the female, though even tergite I having a row of black hairs across the hind margin.

Clypeus strongly protruding, with a *slight* median carina and a weak transverse carina on either side in front, the three very blunt elevations are joined in the middle behind the fore margin of the clypeus. Antennal 3 as long as the three following joints together. Tergite VII at the beginning conical, at the apex only somewhat parallel-sided and then truncate, without pointed angles.

FEMALE : 16-17 mm. Black. Frons predominantly clothed with whitish, vertex so with black, temples with white, hairs. Thorax covered with grey hairs strongly mixed with black hairs; underside with white, propodeum with grey-yellow raised hairs, as well as the tergites I and II, the latter mixed with black hairs, tergites IV and V with black, only at the sides with longer white hairs. Sternites with white fringe. Legs exteriorly with white, metatarsus III interiorly with blackish-brown pilosity, a fascia on the tergites (I-) II and III white.

Clypeus protruding, densely punctured, with (sometimes scarcely) smoothened median keel. Antennal joint 3 not much longer than the three, distinctly shorter than the four following joints combined. Genae developed. Wings pubescent in cell r1. Nervulus interstitial.

LOCALITY : I saw a single male specimen of this species in the Vienna Museum, collected by FRAUENFELD in Alexandria (1855). Hitherto no further Egyptian specimens are known.

Anthophora albosignata Friese

1886. *Podalirius albosignatus* Friese, *Termeszetr. Füzetek*, XIX, p. 265 (male and female).
1897. *Podalirius albosignatus* Friese, Bienen Europas, III, p. 233 (fig.).
1916. *Anthophora albosignata* Storey, Min. Agric. Techn. Bull., 5, p. 17.
1926. *Anthophora albosignata* Alfken, *Senckenbergiana*, VIII, p. 102.

MALE : Length 12.5 - 13 mm. Black, antennal joint 1 beneath and face *white*, clypeus blackened at base in such a way that white narrowly triangular sides of the frons separate it from the orbits; fore margin of the clypeus narrowly black; mandibles black, labrum white. Pilosity of the face white with the exception of some black hairs above at the orbits; pilosity of the vertex, the thorax above and laterally, the tergites I and II ferruginous or yellow, raised, the following tergites with raised black pilosity. Tibiae for the major part clothed with black hairs, also the metatarsus III, the apical margin of which and the tarsal joints 2-4 exteriorly with whitish or grey hairs. Metatarsus II without fan, joint 5 with distinct hair-brush.

Genae developed. Antennal joint 3 more than four times as long as thick at the apex where it is abruptly widened; joint 3 being as long as the four following joints together. Puncturation of the tergites very fine. The anterior wing cells pubescent only near the fore margin. Nervulus interstitial. Tergite VII with slender, parallel-sided, terminal plate that is indistinctly excavated in a very flat triangle, at the apical margin.

FEMALE : 13-14 mm. Black. Pilosity of head, thorax and abdomen on tergites I and II ferruginous to yellow. Tergites usually only at the sides of II and III (exceptionally also on IV) with a fine, often indistinct white fringe of hairs, segments III and following like the sternites with raised black hairs. Legs clothed with black hairs, those on metatarsus III are rather long; at the extreme base of the posterior edge of the hind tibiae with a few paler hairs.

Clypeus with more or less conspicuous median keel. Antennal 3 abruptly thickened at tip, longer than the four following joints, almost five times as long as broad. Tegulae dark, wings somewhat shaded, pubescence as in the male. Apical tergite finely transversely aciculated.

HABITAT : *A. albosignata* was hitherto collected only at the northern coast (Mariout, Mersa Matrouh; March to May) where it is not rare.

The males and females agree with the description given by FRIESE (1897, l. c.) and the former also with the specimens in the collection of the Vienna Museum, identified by FRIESE. Some specimens of my collection were identified as *albosignata* by ALFKEN.

Anthophora tenuicilata Alfken

1926. *Anthophora tenuiciliata* Alfken, *Senckenbergiana*, VIII, p. 101, 118 (male and female).

Alfken gave the following description of this species (in German) :

"Female 14-15 mm. long. Very closely allied to *A. caroli* Pér. and extremely similar to it. Labrum with white, in *A. caroli* with black pilosity. Face below antennae with grey-white, in *A. caroli* with yellowish pile, particularly distinctly at the cheeks. Pleurae towards the sternum with white or yellowish, in *A. caroli* with black, hairs. Tergite II of the abdomen with short and loose grey pilosity, like being covered with a light down, in *A. caroli* with black hairs. Tergites I and II with a very fine fringe-like fascia at the hind margin, in *A. caroli* without such a fascia. Tergites III and IV mostly punctured to the margin, in *A. caroli* smooth and unpunctured in the middle of the apical margin, though this character is inconstant".

"Male 14 mm. long. The yellowish-white labrum with very narrow black margin, in *A. caroli* broadly margined with black so that a trapezoidal yellow-white spot appears from the black. Spots at the base of the clypeus small, in *A. caroli* large. Ultimate tarsal joint of mid legs without brush, in *A. caroli* with distinct black brush. With regard to this character I could examine only 1 male of the species described, that was not in perfect condition".

"*A. tenuiciliata* agrees with *A. caroli* in almost all sculptural characters, the female particularly in the characteristic median keel on the clypeus, and in the red pilosity of the thoracic dorsum and the 1st abdominal tergite. But it is morphologically different so much so that it represents a proper species".

"J. Pérez erroneously sent a female of *A. tenuiciliata* under the name of his *A. caroli* to Friese. Friese gave the description of *A. caroli* in his key (Bienen Europas, III, p. 28) from this specimen. *A. caroli* Friese (sc. p. 28) is therefore a synonym of *A. tenuiciliata*, but not *A. caroli* Friese l. c. p. 98, the latter being a copy of the description given by Pérez. From Schmiedeknecht I received a female from Jericho".

Unfortunately, Alfken's *A. tenuiciliata* remained a puzzle to me. I have not seen the types, but only a specimen (male) in Alfieri's collection bearing Alfken's original label : "*A. tenuiciliata*". This specimen reveals the following characters :

Male : Length 13 mm., width of thorax about 7 mm. Black, antennal joint 1 beneath, face and labrum pale yellow, clypeus at base and sides black so that the pale triangular sides of the frons are separated. Face with white, vertex, thorax and tergites I and II with raised rubiginose pilosity, the hairs on the thorax posteriorly, and on tergites I and II being longer; III and following tergites with black raised pilosity, hind margin of tergite II, and slightly also of III and IV with some marginal yellowish hairs between the black. Under side of femora with dirty-white, sternites at the sides with long white, hairs. Tibiae at the exterior margin and

specially at the apical margin with dirty yellow hairs, on the face of the tibiae the dark ground being visible everywhere. The slender posterior metatarsus shining, set with scattered brown hairs, exteriorly with longer black hairs, apex of metatarsus and the joints 2-4 with a brush of pale hairs. Wings slightly shaded, cells only near fore margin with fine pubescence; veins black.

Clypeus sparingly and shallowly punctured. Genae well developed. Antennal joint 3 clubbed at apex, more than three times as long as broad. The reddish apical joint of tarsi II with distinct brush, but its black hairs not much raised. Nervulus interstitial. Tergite VII representing a slender reddish plate that is exteriorly somewhat concave on each side and shows a very shallow excavation at the apical margin and has very short, pointed angles laterally.

HABITAT : Nouzha, 10. iii. 1919 (coll. ALFIERI) ; an identical male, Alexandria, 17. ii. 1918 (leg. CARNERI, coll. Min. Agric.).

The above described male is extremely similar to *A. albosignata* Fr. so much so that I cannot distinguish it from the latter except by the white hairs mixed with the black ones at the margins of the tergites III and IV, the white hair-stripe at the margin of the black scopa and by the slightly larger size. Since ALFKEN compares his *A. tenuiciliata* with *A. carcli* (and not with *A. albosignata*) we have to assume that *A. tenuiciliata* belongs like *A. caroli* in FRIESE's subgenus *Amegilla*, i.e. that it has rudimentary genae, while the male specimen described above by me, identified by ALFKEN with *A. tenuiciliata*, has distinctly developed genae and is most closely allied to *A. albosignata*.

Moreover, under the name ot *A. tenuiciliata*, possibly identified by ALFKEN, but not bearing his label, there is a female (in coll. Min. Agric.) exhibiting the following characters, and most likely belonging to the above male :

FEMALE : Length 13.5-14 mm. Black, pilosity of face white, of vertex yellow to ferruginous. Thorax and abdominal tergites 1 with short raised ferruginous, but without black, hairs; tergite II with very short raised grey hairs that are mixed posteriorly with dark hairs so that it does not contrast much from the following tergites which bear black hairs. Posterior margin of tergite I (little) and II with a very fine fringe of white hairs, the extreme sides of tergites IV and V showing a few white hairs. Sternites almost wholly clothed with dark hairs. Middle tibiae and metatarsi II exteriorly with dark hairs, mixed with some white hairs. *Hind tibiae exteriorly with* brown to ferruginous hairs, hind margin with dark hairs, metatarsus III with rubiginose hairs at base, rest with black hairs.

Genae developed. Labrum and clypeus densely and rugosely punctured, with a smooth median keel. Antennal 3 very long, nearly five times as long as broad, and nearly as long as the five following joints combined. Wings slightly shaded, cells close to fore margin of fore wing pubescent, a few hairs also in cell m 3. Nervulus interstitial.

HABITAT : 1 female, Alexandria, 21. iii. 1926, leg. A. ALFIERI, coll. Min. Agric.).

This female is very close to *A. albosignata*. If *A. tenuiciliata* is really a species closely allied to *A. caroli* the species described by me is yet unknown. This problem cannot be solved until ALFKEN's types of *A. tenuiciliata* will be examined.

Anthophora cinereiceps Alfken

1812. Unnamed. Savigny, Description d'Egypte, pl. I, fig. 4 (male).
1838. *Anthophora nigrilabris* Spinola, *Ann. Soc. Ent. France*, p. 546 (male).
1926. *Anthophora cinereiceps* Alfken, *Senckenbergiana*, VIII, pp. 102, 124.

MALE : 14-15 mm. Black, tarsal joints 2-5 reddish, also tibiae and metatarsi may be dark red transparent. Antennal joint 1 yellow below, clypeus with conical yellow median stripe, frontal area narrowly yellow, fore margin of clypeus brownish, labrum with more or less broad yellow median stripe that is narrowed towards apex and does usually not reach it; the sides of the face are therefore broadly black. Mandibles black. Pilosity : Clypeus with white, orbits above and vertex with more or less black, hairs, thorax and tergites I and II with raised grey, the remaining tergites with black, hairs, and some raised white hairs at the hind margins, but without fasciae. Sternites with mixed pilosity. Tibiae and metatarsi clothed exteriorly with semidetached dark, at the margins and at the apex with longer white and dark, hairs. Joint 5 of tarsi II with quite inconspicuous brush, i.e. with some black semi-erect hairs on both sides. Wings only slightly shaded, veins dark.

Clypeus finely punctured, shining in the middle, protruding; labrum only slightly transverse. Genae developed. Antennal joint 3 abruptly thickened at tip, scarcely three times as long as broad, somewhat shorter than the three following joints combined. Nervulus about interstitial. Tegulae pubescent. Tergite VII ending in a slender, parallel-sided plate that is only very slightly emarginated at the apex.

FEMALE : 16-17 mm. Black, hind femora and venter sometimes dark reddish. Pilosity of the labrum partly whitish, partly brownish, clypeus with mixed pilosity, brownish in the middle, whitish laterally and above, vertex with mixed pilosity. The grey pilosity of the thorax is strongly mixed with dark hairs, the sides of the propodeum and the tergites I and II show paler, the tergite III and the following tergites bear a black, raised, pilosity, the margins are finely and indistinctly fringed with white, but have no bands, only the sides of the tergites IV and V have some longer white hairs.

The sternites are laterally fringed with white. Hind tibiae and base of metatarsus III exteriorly clothed with more or less dark *ferruginous* hairs.

Clypeus medially with a punctured longitudinal callus. Nervulus interstitial. Tegulae shining, blackish. Antennal joint 3 more than four times as long as broad, as long as the four following joints combined.

HABITAT : The species was taken from November to April at Nawa, Giza, Meadi and Helouan.

Specimens of this species, described by ALFKEN in 1926, were about 10 years later identified by him with *orientalis* Mor. In the Vienna Museum I saw specimens of *orientalis* Mor. from Sicily and Corfu, identified by FRIESE. These represent, as the description given by MORAWITZ shows too, a smaller species (male 12 mm, female 12-13 mm) in which the female is clothed with yellow-grey hairs on the thorax and the tergites I and II; the hairs on the abdomen are longer and more strongly raised, the sternites show no pale hairs at the sides, the scopa is paler ferruginous. In the male of *orientalis* the clypeus is yellow with black angular basal spots that are fused with the black sides of the frons; the brush of the 5th midtarsal joint is stronger, the tergites show laterally at the hind margins no pale hairs, and the 3rd antennal is somewhat longer than the three following joints, although the whole antenna appears shorter than in *cinereiceps*.

In the collection of the Ministry of Agriculture there are specimens of *cinereiceps* labeled "*cinereiceps* Alfk. = *nigrilabris* Spin". Although this was correct, ALFKEN altered his opinion later on assuming that *nigrilabris* Spin. (1838, *Ann. Soc. Ent. France*, p. 546, male) was identical with *lanata* Klug (= *canescens* Alfken, nec Brullé). In SPINOLAS paper (l. c.) the name *nigrilabris* appears twice, having been used for two different species, thus *nigrilabris* (p. 546, male) is preoccupied by *nigrilabris* (p. 543, female). The latter species has to keep the name and cannot be renamed, as DALLA TORRE did (*saropodoides* DT.), the former, published on a later page is the one identical with *cinereiceps*, as can be seen from the description.

Anthophora lanata (Klug)

1845. *Megilla lanata* Klug, Symb. phys., Dec. 5, Ins., pl. 49, fig. 4 (female.)
1897. *Podalirius lanatus* Friese, Bienen Europas, III, p. 206.
1926. *Anthophora canescens* Alfken (nec. Brullé), *Senckenbergiana*, VIII, p. 101 (male).
1930. *Anthophora nigrilabris* Alfken (nec Spin.), *Stettiner Ent. Zeit.*, 91, p. 224 (male).

MALE : Length 14-15 mm. Black; labrum, clypeus in the middle, a narrow, transverse (not triangular) frontal area and antennal joint 1 beneath, yellow; sides of clypeus and its fine fore margin, 2 dots at base of labrum, black. Face clothed with long white, orbits with black, hairs. Vertex, thorax and abdomen with raised, whitish-grey pilosity, black hairs only sparingly present on the thorax; on the abdomen such black hairs are only from tergite III onwards more profusely intermixed. Under side and legs with long white hairs. Exterior face of tibiae and the metatarsi little densely set with whitish hairs, only the apices of the joints with denser pilosity.

Clypeus finely and densely punctured, the punctures of unequal size. Antennal 3 abruptly thickened at tip, about three times as long as broad, and as long as the three following joints combined. Tegulae blackish. Wings pale, only cell r 1 pubescent. Nervulus only very slightly prefurcal, nearly interstitial. Apical

segment of the middle tarsi thickened, with black hairs on both sides, though this brush is not very conspicuous. Metatarsi slender, parallel-sided, straight. Tergite VII somewhat conical, sides slightly concave, the face finely, somewhat rugosely, punctured, at the apex above with a slight horse-shoe-shaped impression, or margin slightly reflexed, apex truncate, sides not pointed.

FEMALE : Length 17-18 mm. Black. The whole body with raised grey pilosity which is only on the thorax mixed with black hairs, hairs of the abdomen purely white-grey. Middle tibiae at the exterior margin, hind tibiae and metatarsus III exteriorly everywhere clothed with long *ferruginous* hairs. Tergite V in the middle with rust-brown to dark brown hairs.

Clypeus with smooth median keel. Genae developed. Antennal joint 3 slender, abruptly thickened at tip, at least four times as long as broad, well as long as the four following joints combined. Tegulae brown with yellowish margins. Wings nearly hyaline, only cell r1 pubescent. Nervulus as in the male.

HABITAT : Northern coast (Alexandria, Amriah, Borg-el-Arab, Mersa Matruh), February-March.

On account of the dense, grey-white pilosity of the abdomen, any apical fasciae are not noticeable, and by this character *lanata* may easily be distinguished from either *speciosa* or *dispar*.

ALFKEN originally held this species to be *canescens* Brullé, but corrected this error (l.c. 1930) in the opinion to have rediscovered SPINOLA'S *nigrilabris*. However, this species agrees much better with *cinereiceps* Alfken.

Anthophora atriceps Pérez

1879. *Anthophora atriceps* Pérez, *Actes Soc. Linn. Bordeaux*, XXXIII, p. 139 (male).
1895. *Anthophora atriceps* Pérez, Espèces nouvelles mellifères Barbarie, Bordeaux, p. 3 (male and female).
1897. *Podalirius atriceps* Friese, Bienen Europas, III, p. 220 (fig.).
1916. *Anthophora atriceps* Storey, Min. Agric., Techn. Bull. 5, p. 18.
1926. *Anthophora atriceps* Alfken, *Senckenbergiana*, VIII, p. 101.

MALE : 11-12 mm. Body inclusive of face and antennae black, the intermediate tarsal joints yellowish, the margins of the tergites somewhat brownish. Pilosity of clypeus and labrum whitish-grey, of frons black (mixed with a few white hairs), thorax and tergites I and II clothed with long raised white hairs that are mixed on the scutellum with black hairs, the rest of the abdomen bears only black raised hairs. Tegulae blackish-brown. Wings hyaline, veins dark. The tibiae exteriorly clothed with black and few grey, the posterior and apical margin with white hairs; metatarsus III slender, with white hairs at the apex, otherwise dark; metatarsus II with fan that is weaker than in *A. sicheli* Rad., tarsal joint 5 only exteriorly with a series of black raised hairs, the brush, therefore, not full. Sides of thorax with

white, under side with black hairs. Tegulae blackish-brown, wings clear, slightly shaded towards apex.

Clypeus somewhat protruding but little convex, densely punctured. Antennal 3 thin, abruptly widened at tip and there rather broad so that it is not quite three times as long as broad, joint 4 transverse. Wing cells nearly bare, only in cell r1 a few microscopic hairs. Nervulus very little prefurcal. Tergite VII with slender conical plate which is truncate at the apex and scarcely emarginated, and the surface of which is dull, hardly punctured.

FEMALE : Length 11-12 mm. Black. Face, thorax, tergites I (and II) of the abdomen with raised white, the tergites I-V laterally at the posterior margins with very distinct semi-attached pilosity so that fasciae appear which are always broadly interrupted in the middle. Hind tibiae exteriorly clothed with long white, only at the upper (posterior) margin with brownish hairs. Metatarsi II and III with black hairs. The posterior sternites laterally with a white fringe.

Clypeus densely punctured, with indistinct median carina. Antennal 3 very slender, thickened at apex, about four times as long as broad, and as long as the four following joints together. Genae developed. Wings as in the male.

HABITAT : Northern coastal region (Alexandria, Dekheila, Mariout, Mersa Matrouh), fairly common (February-April).

This species may hardly be confused with any other one, with the exception of *sicheli* Rad. in the male sex, in which the pilosity of the frons is more extensively white and in which there are no black hairs among those of the scutellum. *A. sicheli* is not yet known from Egypt.

Anthophora arabica spec. nov.

MALE : 13.5-14 mm. Black, antennal joint 1 beneath, a narrow, transverse frontal area, the clypeus medially (broadly in front, narrowly behind), a fine short line at the orbits, *white*; the clypeus has therefore two large black spots united with the black sides of the frons; also the sides of the clypeus anteriorly and the *labrum* are *black*. Frons, clypeus and labrum densely clothed with long white hairs, the orbits with some black hairs, and the vertex profusely mixed with black hairs and therefore appearing grey, like the thorax. Tergites I and II with grey erect pilosity, II with very few, III and IV with more black hairs towards the hind margin, V only with black hairs on the disk, but the extreme sides with white raised hairs; loose postero-marginal bands of white colour are present on tergites I-IV. Under side with white-grey pilosity. Tibiae and tarsi at the hind margin with loose and raised long white hairs so that the dark ground becomes visible everywhere; tips of the hind tibiae and metatarsi III with short white pilosity, the interior face of the metatarsi with short black pilosity. Calcaria brown. Tegulae testaceous, darker within.

Genae developed. Sides of frons touching the mandibles. Clypeus strongly elevated, puncturation because of the dense pile not visible. Labrum little trans-

verse. Antennal joint 3 thin with club-like apex, more than three times as long as broad, about as long as the four following joints together. Pubescence of wings only in cell r 1 conspicuous. Nervulus nearly interstitial. Tergites between the raised pilosity shining, tergite II very finely and densely set with somewhat rough punctures. Margins of the tergites pale transparent. Plate of tergite VII slender, almost parallel-sided, with flat, almost triangular excision so that there appear at the angles two very short and small, somewhat rounded lobes. Hind tibiae somewhat convex exteriorly with a short, not very sharp tooth-like lobe at tip.

HABITAT : One specimen (holotype) I discovered in the Wadi Umm Assaad (9. iv. 34) on *Stachys aegyptiaca*, another equal specimen (paratype) is in the collection of the Ministry of Agriculture, and was taken (21-25. iii. 35) in the Wadi Galala (leg. Farag). Both specimens are in perfect condition.

The holotype was identified by ALFKEN with *A. nigrilabris* Spin. I am, however, of the opinion that ALFKEN'S species *cinereiceps* much better agrees with *nigrilabris* Spin. (sc. male. l.c., p. 546), since joint 5 of the middle tarsi has in this species a distinct black lateral pilosity (brush) which is not the case in both specimens of *arabica*. The male of *cinereiceps* differs from *arabica*, besides, by the lack of conspicuous abdominal fasciae on the tergites (I-) II-IV, the much more distinctly contrasting posterior abdominal segments, i.e. contrasting against segments I and II, the not so distinctly angular hind tibiae, the larger size and the much shorter antennal joint 3.

Anthophora desertorum spec. nov.

MALE : Length 11-11.5 mm. Black, tarsal joints 2-5 yellowish-brown at base; antennal joint 1 beneath, a narrow, transverse frontal area, clypeus, labrum (except the fine margins and 2 basal dots), yellow, sides of frons black but with small yellow line at the orbits; margin of clypeus towards the sides of the frons lined with black at base but *without black angular basal spots*. Mandibles black. Frons, sides of clypeus and labrum with long raised white, orbits with black, vertex with mixed, pilosity. Thorax clothed with long grey — and few black — hairs, tergites I and II with long grey-white raised hairs, tergites III-V with such black hairs; sides and especially posterior margins of the tergites with long white hairs, tergite VI at middle with nearly decumbent black pilosity. Under side of body with raised white pilosity or fringes, respectively. Middle and hind tibiae on a black ground clothed with little dense white, margins and apices of the hind tibiae and metatarsi with dense and somewhat decumbent white hairs; base of metatarsus III exteriorly with a few long white hairs, interior face with brownish hairs. Tarsal joint 5 of mid legs with a distinct brush of black semi-erect hairs. Wings hyaline, veins black, tegulae dark brown. Calcaria darkened.

Clypeus strongly protruding; convex, shining, laterally densely, medially less densely, punctured. Labrum little transverse. Antennal 3 abruptly thickened

at the apex, about three times as long as broad, and about just as long as the three following joints combined. Sides of frons reaching base of mandibles. Genae moderately well developed. Thorax and abdomen very finely punctured, the former dull, the latter shining. Wings only in cell r1 with a few setulae. Nervulus interstitial. Tergite VII produced into a narrow, nearly parallel-sided, plate the apical margin of which has a shallow, nearly triangular excavation so that distinct angles are formed.

FEMALE : Length 11.5-12 mm, width 4-4.3 mm. Black, tegulae dark. Face with raised white, vertex with mixed, thorax with grey-white and little black raised pilosity. Tergites I and II clothed with raised grey-white, tergite III with mixed, the following tergites mainly with black, hairs, and narrow, nearly decumbent postero-marginal fasciae on the tergites I-IV; tergite V with black to brown pilosity, only at the sides with white hairs. Under side grey-white, sternites fringed with white hairs at the sides, somewhat darker ones in the middle. Hind tibiae exteriorly with bristly white pilosity, like the posterior metatarsus on which the dark ground is not quite covered by the hairs; the interior face of the metatarsus shows a dense reddish-brown pile. Wings as in the male or margins darker, cell r1 with conspicuous, cells m1 and sc with indistinct pubescense.

Clypeus with dense, rugosely granulated puncturation, and with a fine, smooth, median keel. Antennal joint 3 thin, abruptly thickened at tip, well four times as long as broad, and about as long as the four following joints combined. Thorax dull, abdomen shining.

HABITAT : Valleys of the Eastern Desert (Wadi Umm-Assad, Wadi Hof, Wadi Rasheed, Wadi Garawi, Wadi Abu Gufân, Wadi Abu Zoleiga), March-April.

The male of this species was identified with *A. orientalis* Mor., by ALFKEN. However, I could examine male specimens of *orientalis* in the collection of the Vienna Museum, identified by FRIESE. In these, the posterior tergites do not show any pale hairs, the 3rd antennal is longer than the three following joints combined, the clypeus has black basal spots and the apical margin of the VIIth tergite is rounded. Females of our new species were in the 20'ies named *calcarata* Lep., by ALFKEN, though he corrected this identification in giving to specimens of the same insect, collected later by myself in the Wadi Umm Assad, the two tentative names : *rogenhoferi* Mor. and *cinerea* Friese, indicating herewith that he could not make up his mind on the identity of this insect. Specimens of *A. rogenhoferi* Mor. (in coll. Mus. Vienna) show that this species differs from *desertorum* by its larger size (12-13 mm), purely black pilosity on tergite III, the white marginal bands being conspicuous only on tergite II, but very fine on the posterior tergites, in having wholly black hairs on the sternites and no keel on the clypeus. *A. cinerea* Friese is not identical either, as I could see from original specimens (Sarepta, det. FRIESE). It is a larger species too (12-13 mm, width of thorax 5-5.5 mm) and the abdominal fasciae of the female are more distinctly raised. The new species has as to the female sex also to be compared with *calcarata* Lep., but the presence of black hairs on

the tergites I and II in the latter species which has, though recorded, not yet been found in Egypt, and the not carinated clypeus easily distinguish it from *desertorum*.

Anthophora facialis spec. nov.

MALE : Length 11-12 mm. Black. The whole face densely covered with black, vertex with grey, its sides and the temples with black hairs. Pilosity of the thorax grey (or perhaps also yellowish-grey), that of the tergites I-III of the same colour, without black hairs, of tergite IV at base predominantly grey, distally black, of V and VI black; hairs of abdomen long, raised. The whole under side with raised black pilosity. All legs covered with black hairs, this pilosity becoming denser towards the end of the middle and hind tibiae. Tegulae dark. Wings hyaline, veins black.

Genae developed, moderately long. Clypeus finely rugosely punctured. Antennal joint 3 more than three times as long as broad, rather abruptly widened at the tip. All wing cells bare. Nervulus interstitial. Joint 5 of mid tarsi with some semi-erect black hairs at the sides, though not with a very distinct brush. Tergite VII without carina but with a fine sulcus about in basal half, apically ending in two reddish tips that are separated by a comparatively narrow triangular excision.

FEMALE : Length 13-14 mm. Black. Head clothed in front with black, vertex with grey, thorax and tergites I and II with short raised grey hairs, tergite III and following tergites with short, raised black pilosity. The whole under side and the legs set with black hairs. Tergite VI (of the unique specimen) reddish at base, at the sides with short reddish hairs. Tegulae dark. Wings as in the male, cell r1 with a few microsetae.

Clypeus with dense and fine rugose puncturation, dull, with sharp median carina. Puncturation of the tergites extremely fine. Tergite VI narrow, sides slightly concave, face very finely transversely chagreened. Antennal joint 3 as long as the four following joints together.

HABITAT : One male and one female (18. iii. 35 and 9. iv. 34, respectively), Wadi Umm Assad, leg. H. PRIESNER.

ALFKEN examined the two specimens but did not name the male; the female he labeled : " ? *romandi* Lep. or spec. nov.", suspecting already the new species. *A. romandi* Lep. which I saw in the Vienna Museum (det. FRIESE) is a larger and broader species, its antennal joint 3 is somewhat shorter than the 4 following joints combined, and the head and sides of the sternites are distinctly set with *white* hairs.

Anthophora scopipes Spin.

1838. *Anthophora scopipes* Spinola, *Ann. soc. ent. France*, VII, p. 545 (male).
1897. *Podalirius fulvitarsis* var. *scopipes* Friese, Bienen Europas, III, p. 171.
1926. *Anthophora scopipes* Alfken, *Senckenbergiana*, VIII, p. 101, 121 (male and female).

MALE : Length 15.5-16 mm. Black, tibiae somewhat reddish transparent or brown, middle and hind metatarsi distinctly ferruginous, tarsal joints 2-4 and

base of 5 ferruginous, the margins of the abdominal tergites and sternites pale, transparent, particularly tergite II. Antennal joint 1 beneath, the whole face, a transverse frontal area and the mandibles (with darkened tips), *white*. Labrum with two dark basal dots. Pilosity of face and temples dirty white and raised, of vertex, thorax and tergites I and II pale yellow or ochrous; on thorax and abdominal segments I and II the hairs are short. Tergites III-VI with short and inbetween some longer black hairs, tergites VII with ferruginous hairs. Tergite II shows a very delicate white apical fringe of short white hairs. Pilosity of the legs yellow to ferruginous, at the margins raised. Tegulae yellow to ferruginous. Wings almost hyaline, veins dark. Margins of sternites II and III with a yellow fringe at the sides.

Clypeus strongly protruding, with sparse and shallow puncturation. Labrum with fore margin rounded, somewhat transverse. The triangle of the sides of the frons reaches the base of the mandibles. Antennal 3 abruptly thickend at apex, moderately long, not quite three times as long as broad. The raised hairs on the 2nd tergite are distinctly plumose. Metatarsi very slender, joint 5 of middle tarsi with a disk-like black brush. Tergite VII with slender ferruginous plate that is truncate at the apex, scarcely emarginated, its apical angles are not acute, the face is finely carinated longitudinally. Wings only in cell r1 distinctly pubescent. Nervulus very slightly prefurcal.

Female : Length 16-17 mm. Much broader. Black, with brown or dark ferruginous clypeus and labrum, and reddish middle of the mandibles; the antennal joints 1 and 2 may also be brownish. Legs dark ferruginous. Pilosity of the body dull yellow, vertex with a few black hairs. Thorax with short raised grey-yellow to ferruginous pilosity, and not very strongly mixed with black hairs. Tergite I clothed with raised yellowish hairs, tergite II as well, but the hairs of it short, plumose and more grey than yellow; tergite II with a fine, whitish, marginal hair-line, and in front of this with somewhat decumbent black pilosity; tergite III with very short black hairs, IV as well, but with longer raised black hairs in addition; tergite V with dense, velvety black pilosity, hind margin with reddish, sides with longer such hairs. Margins of the sternites at the sides fringed with white-yellow, in the middle with ferruginous, hairs.

Labrum coarsely and rugosely, clypeus moderately coarsely and densely punctured, with smooth median line. Antennal 3 almost four times as long as broad, as long as the four following joints together.

Habitat : Wadi Digla, Wadi Umm Assad, Wadi Hof, Wadi Rasheed, Wadi Galala, (March-April).

This species forms together with the following two species (*spinolana* and *flabellata*) a special sub-group. It was erroneously placed as a variety to *A. fulvitarsis* Brullé, by Friese. This author had obviously never seen Egyptian specimens, but based his opinion only upon the description given by Spinola.

ALFKEN (*Senckenbergiana*, VIII, p. 120, 1926) correctly recognized the species, or better, the species-group since it appeared that there exists not only one, but that there are three similar but distinct species of one group.

The question arises now which of the three species represents the true *scopipes* of SPINOLA, and which of them agrees with the one more fully described by ALFKEN (l. c.). One of the three species has the face yellow and can, therefore, neither be SPINOLA's nor ALFKEN's *scopipes*, because both authors describe the face as white. For the yellow-faced one, which is obviously a new species, I suggest the name *flabellata* sp. n. The female of this species was labeled "aff. *agama* Rad." by ALFKEN — who received it singly, i.e. without males — and this tentative identification shows his uncertainty about this form, the female of which actually differing much from the two other species.

I assume that SPINOLA's *scopipes* is identical with the one of the two white-faced species which has yet recognizeable fine white bands on the posterior margins of the tergites, since SPINOLA compares his species with the figure given by SAVIGNY (Descr. d'Egypte, pl. I, fig. 3) : "Mais celui-ci est plus grand; les bandes blanches de son abdomen sont mieux prononcées". This probably means that in SPINOLA's species there were abdominal fasciae, though narrow, yet recognizeable. SPINOLA's *scopipes* cannot be therefore the one of my species having no bands at all, and which I am describing below under the name of *spinolana* sp. n. I should like to remark, however, that SAVIGNY's figure 3 does not at all refer to a species of the *scopipes* group, but most likely to *A. aegyptiaca* DT. et Fr., since the metatarsus of the mid leg of the species illustrated shows a brush of hairs while in all species of the *scopipes*-group such a fan is entirely absent.

A. scopipes, as described by ALFKEN, is most likely identical with that of SPINOLA, especially on considering the description of the male (white face, transparent posterior margins of the tergites). It is also certain, however, that the specimens of ALFIERI's and my own collection, as far as they were examined by ALFKEN, comprise all three species; they were all labeled "*scopipes*" by ALFKEN who obviously regarded the grey colour of *spinolana* as having faded out, although these specimens are quite fresh ones.

ALFKEN's *scopipes* is, therefore, identical partly with *scopipes* Spinola (male and female), *flabellata* (male) in sched. and *spinolana* (male and female) in sched.

Anthophora spinolana spec. nov.

MALE : 14-15 mm. Black, apical margins of the abdominal tergites not transparent; tips of fore tibiae, the hind tibiae and metatarsi often reddish transparent, tarsal joints 2-4 and base of 5 ferruginous. Face, a spot at the base of the mandibles and the 1st antennal joint beneath, *white*. Head with white, thorax and abdominal tergites I and II with short, raised, grey-white pilosity, without

intermixed black hairs; pile of tergite I somewhat longer than on the remaining segments; tergites III-VI with raised black pilosity which strongly contrasts against the greyish colour of head, thorax and tergites I and II, the greyish hairs on tergites I and II are plumose for the major part, at the apical margin, however, they are nearly decumbent and paler, but there are no fasciae present. Sternites, especially at the sides, slightly fringed with white hairs, thorax beneath with whitish hairs. Legs, inclusive of coxae, clothed with ferruginous hairs which are rather long at the hind margins. Joint 5 of middle tarsi not thickened, but, like in *scopipes*, with a large, disk-like, black hair-brush. Tegulae testaceous, sometimes darker interiorly. Wings hyaline, veins black.

Clypeus little protruding, densely punctured, little shining. Labrum transverse, coarsely rugose, shining. Genae developed. Sides of face ending on the same level as the sides of the clypeus. Antennal 3 somewhat knobbed at tip, not quite three times as long as broad. Wings only in cell r1 distinctly pubescent. Nervulus interstitial. Metatarsi slender. Tergite VII apically forming a rather broad plate which is truncate and slightly undulated at the apical margin, and the hind angles of which protrude only very slightly so that there appears no distinct tooth; the surface is pubescent and finely carinated longitudinally.

FEMALE : Length 14-15.5. mm. Apart from the secondary sexual characters it is very similar to the male. Face and antennae black. Antennal 3 more than 4 times as long as broad, as long as the four following joints combined. Pilosity of the body as in the male, at the end of the abdomen segment VI shows, besides the black ones, some red hairs. Margins of the sternites with white fringe, posteriorly in the middle with ferruginous fringe. The legs are in their ground colour mostly darker than those of the male.

HABITAT : This species was collected at the northern coast as well as in Middle Egypt (Kerdasa, Abu Rowash, Manshiet-el-Bakri, Giza Pyramids, Helouan). December-March. (Types in my collection, paratypes in coll. Min. Agric. and ALFIERI).

Though similar to *A. scopipes* Spin. it is at once distinguished by the greyish colour of the pilosity of the anterior body, the lack of fasciae of white hairs on the tergites, the uniformly coloured i.e. not apically transparent segments; in the male it differs, besides, by the structure of segment VII of the abdomen.

Anthophora flabellata spec. nov.

MALE : Length 13-15 mm. Black, middle and hind tibiae more or less dark brown, tarsi reddish brown to ferruginous, ultimate joints darkened towards their apices. Margins of sternites and tergites broadly pale transparent, tergite VII almost wholly ferruginous. Antennal joint 1 beneath, frontal area, sides of face, clypeus and labrum, *yellow*, mandibles reddish-brown with yellow basal spot; suture between clypeus and sides of frons lined with black; the yellow sides of the frons

have a black spot at the base so that they appear emarginated there. Head clothed with white, vertex at the sides with some black hairs; thorax with yellowish-grey hairs, moderately mixed with black hairs, tergite I with long, tergite II with short (plumose) yellowish-grey hairs; tergites II and III (and laterally also IV) with very fine white marginal fascia of decumbent hairs, tergites III-V with raised black hairs, VI and VII at the margins with ferruginous hairs. Tegulae testaceous to ferruginous. Wings hyaline, veins dark brown. Legs clothed with decumbent and erect ferruginous hairs, joint 5 of the middle tarsi like in *scopipes*. Calcaria yellow.

Clypeus protruding, rugosely punctured, shining; labrum very little transverse, strongly shining. Genae developed, moderately long. Antennal 3 much thickened at the apex, scarcely three times as long as broad. Metatarsi very slender. Terminal plate of tergite VII rectangular, with dark median carina, the apical margin almost straight, scarcely noticeably excavated. Tergites and sternites strongly shining, the former moderately densely punctured, the latter very finely chagreened, very indistinctly punctured. Nervulus very slightly prefurcal.

FEMALE : 13-14.5 mm. Black, middle of mandibles and labrum brown, all legs reddish-brown, sometimes the fore legs darkened, tergites and sternites of the abdomen broadly pale transparent at the margins. Frons and temples clothed with raised whitish, vertex with mixed, and thorax with (moderately long) yellowish-white and black hairs. Tergite I with raised grey-ferruginous, tergite II with short raised such pilosity, tergite III on the disk with very short raised black hairs. Very fine white fasciae are present on tergites I-IV, which are full on II and III, medially interrupted on IV; tergite V posteriorly with broadly reddish or ferruginous, tergite VI at the base with black, at the sides with reddish-brown, pilosity. Sternites fringed with ferruginous hairs, with a few white hairs laterally. Legs bristly clothed with ferruginous hairs. Wings slightly shaded, with pubescence in cell r1.

Clypeus densely and rugosely punctured, with fine, smooth median keel. Antennal 3 abruptly thickened at tip, well four times as long as broad and about as long as the four following joints together. Apical tergite slender, finely margined. Nervulus interstitial or slightly prefurcal.

HABITAT : Wadi Umm Assad, Wadi Hof, Wadi Gerawi, Wadi Hussein. March and April. (Holo - and Allotype, from Wadi Umm Assad and Wadi Gerawi, respectively, in the author's collection; paratypes in the collections of the Ministry of Agriculture and ALFIERI's).

The male of this species differs from *scopipes* and *spinolana* by the yellow (instead of white) face, the fine line of white hairs on tergites I-III (-IV); from the latter, besides, by the transparent posterior margins of the tergites, and the slender apical plate of tergite VII. The female is distingushed from *scopipes* by the fine white-haired hind margin of the tergites II and III, and the patch of ferruginous hairs on tergite V, from *spinolana* by the yellowish-grey pilosity of the thorax, the presence of narrow white bands on the abdomen and the transparent hind margins of the tergites.

Anthophora hispanica (F.)

1787. *Apis hispanica* Fabricius, Mant. Ins., I, p. 300.
1897. *Podalirius hispanicus* Friese, Bienen Europas, III, p. 193, fig. (male and female); further references.
1916. *Anthophora hispanica* Storey, Min. Agric., Techn. Bull. 5, p. 18.
1926. *Anthophora hispanica* Alfken, *Senckenbergiana*, VIII, p. 101.

MALE: Length 18-21 mm. Black, face yellow with two black basal spots that are fused with the sides of the frons, the orbits narrowly triangularly yellow; fore margin of clypeus lined with black; labrum with two black basal dots. Mandibles black. Antennal joint 1 yellow below. Face with raised yellowish pilosity, a few black hairs at the insertion of the antennae and on the vertex which is clothed with ferruginous hairs. Thorax and tergites I and II clothed with reddish-brown to ferruginous short raised hairs; tergites III and the following tergites, as well as the venter clothed with black, the legs mainly with black, the posterior margin of the hind tibiae also with some paler and *longer*, hairs. Middle tibiae behind with long, loose fringe, metatarsus II with a curled fan having the shape of a triangle.Metatarsus III at base of the hind margin with long and not dense hairs. Sides of the thorax with brown to ferruginous hairs, femora beneath with paler or grey-white pilosity. Calcaria brown. Tegulae pale brown to ferruginous. Wings almost hyaline, veins black.

Clypeus strongly protruding, finely, little densely punctured; labrum shining, very finely, sparingly punctured, almost as long as broad. Genae well developed. Antennal 3 knobbed at the apex, about 4 times as long as broad. Only r1 of the wing cells distinctly pubescent. Tergite VII narrowed towards apex where it is truncate, and above at the apex with two shallow foveolae.

FEMALE : 19-20 mm. Very similar, the whole underside and the legs, as well as the tergites from III onwards with black, frons with mixed, yellowish-grey and black pilosity, the black one near the base of the antennae and on the vertex.

Clypeus with coarse and dense puncturation, and smooth median line. Antennal 3 about five times as long as broad, about as long as the five following joints combined. Nervulus interstitial.

HABITAT : Northern belt (Borg-el-Arab, Ikingi; February-April).

By the large, triangular hair-fan of the middle metatarsus this species is very characteristical in the male, the female, however, being very similar to *A. alfierii*, differing by somewhat larger size, thicker metatarsi, more distinctly raised pilosity of the legs, and the greater number of pale hairs on the head.

Anthophora alfierii Alfken

1942. *Anthophora alfierii* Alfken, *Veröff. dtsch. Kolon. Mus. Berlin*, p. 209.

MALE : Length 16.5-17 mm. Black. Face clothed with black, vertex partly with black, partly with red hairs, thorax and tergites I and II with short ferruginous

to yellow, tergites III-VI with black pilosity; on tergite II there are longer black hairs intermixed posteriorly; although the whole abdomen shows raised pilosity, the hairs are short, only those on the tergites IV-VI are longer. Legs and under side of body clothed with black hairs.

Clypeus somewhat flattened in front, in the shape of a low triangle, somewhat transversely rugosely punctured, shining. Labrum with two basal lateral calli. Genae well developed. Antennal 3 fine, abruptly thickened at tip, more than four times as long as broad, almost as long as the four following joints together. Tegulae testaceous. Wings pale, veins dark, only cell r 1 pubescent. Nervulus interstitial. Legs slender, metatarsi long and thin, exteriorly sparingly set with long black hairs. Tergite VII with narrow, slightly conical terminal plate that is slightly sinuated at the sides near the apex so that it becomes slightly broader again at the apex, the apical margin being truncate; the dorsal face is more finely punctured, nearly smooth, and shining towards the apex.

FEMALE : Length and pilosity as in the male, the pale parts also varying from ferruginous to yellow. Clypeus somewhat smoother in the middle than at the sides but without median keel. In fresh specimens there is a very fine white hair-line visible at the margin of tergite II, which is pale ferruginous on tergite I. All legs and under side with black pile.

HABITAT : Suez Road, Meadi, Wadi Umm Assad, Wadi Hof, Wadi Rished, Wadi Gerawi, Wadi Hussein, Wadi Abu Handal, Wadi Zoleiga, Wadi Rishrash; Oasis Baharia; Sinai.

The female comes very close to *hispanica*, chiefly differing by somewhat smaller size, slenderer, less bristly haired legs and, as a rule, paler pilosity of the head. The male differs by the slenderer legs, the lack of the metatarsal fan, and smaller size.

The species is extremely close to *A. cyrenaica* Gribodo (*Boll. Mus. Zool. Torino*, XXXIX, p. 5, 1925), the male of which being represented by *A. caelebs* Grib. (l.c., p. 6), and is probably identical with it. However, the identity could only be confirmed by direct comparison. ALFKEN has obviously overlooked the description of *A. cyrenaica*, or else he would have referred to the great similarity of the two forms.

Group III (wegelini)

Anthophora wegelini Friese

1914. *Anthophora wegelini* Friese, *Stett. Ent. Zeitg.*, LXXV, p. 218.
1916. *Anthophora* sp. Storey, Min. Agric., Techn. Bull. 5, p. 18.
1926. *Anthophora ambigua* Alfken (nec Pérez), *Senckenbergiana*, VIII, p. 101.

MALE : 10.5-11.5 mm. Black; margins of the tergites (in rubbed specimens) whitish-yellow transparent; antennal joint 1 beneath, clypeus in front and in the

middle to base, frontal area transversely, sides of frons narrowly (V-shaped), yellow; mandibles with yellow dot or short line; labrum yellow with two black basal dots and dark fore margin. Wings hyaline, veins black. Head with dense white raised pilosity so that the ground is nearly wholly covered; vertex laterally near the orbits with only a few black hairs. Thorax and abdomen with raised white pilosity, without black hairs on the thorax or with single such hairs at the scutellar base; abdomen always without black hairs, apical bands moderately broad, conspicuous, in the middle somewhat broader than at the sides. Legs with decumbent and raised white pilosity, metatarsus III exteriorly thinly set with white hairs so that the dark ground is visible everywhere, only the apex more densely white. Tegulae dark brown to black. Calcaria yellow.

Clypeus protruding. Antennal 3 about 2.5 times as long as broad, as long as or scarcely longer than joints 4 and 5 combined, abruptly thickened at tip. Wings little pubescent at the fore margins of cells m1 and sc, distinctly so in cell r1 Tergite, VII with two conspicuous fine teeth that are separated by a semi-circular excision without carina.

Female : Length 9-10.5 mm. Black. Pilosity as in the male, only the thorax with a few black hairs, especially some at the scutellar base. Abdomen without black hairs on segments I-V, only in the middle of V with a cushion of black hairs. Hind tibiae and metatarsi clothed with coarse slightly raised hairs, sternites with white fringe, only in the middle with more or less darker fringe.

Clypeus convex, with fine to moderately coarse puncturation. Antennal joint 3 thin, abruptly thickend at tip, about four times as long as broad and about as long as the four following joints together. Tegulae yellow-brown to brown. Tergite VI without carina, dull.

Habitat : The species is common all over Egypt, also in the oases, and it is one of the first species to appear, i.e. it starts to fly after the first rains about the middle of December, and continues until March. It is commonly seen hovering about *Zilla spinosa* (6).

The females had been confused with other similar species, e.g. *A. priesneri;* this species can be distinguished by the yellowish tinge of the white pilosity, the more densely punctured, less shining clypeus and the intermixed black hairs on the tergites III-IV.

Alfken referred this species (*wegelini*) to *ambigua* Pér. I cannot agree to this synonymy, since Perez indicates that *ambigua* has black hairs on the disk of the abdominal tergites, and tergite V shows at least at the sides black hairs. *A. wegelini* comes in its pilosity much closer to *rivolettii* Pér., also an Algerian species, which Perez compares with *ambigua*, stating that the fasciae of the abdomen of *rivolettii* are in the middle broader than at the sides, tergite V at base with white hairs (not black as in *ambigua*). *A. rivolettii* differs from *wegelini* in the female by

(6) Not *Scilla* (cf. Alfken, *Senckenbergiana*, VIII, p. 101; 1926.

the distinctly carinated clypeus, and the extraordinarily elevated pygidium that ends in a sharp carina (cf. PEREZ, Esp. nouv. Mellif. Barbarie, Bordeaux, 1895, p.2).

My specimens of *wegelini* are identical with specimens in the Vienna Museum, labeled "types" by FRIESE. Similar to *wegelini* is *A. cunicularia* Friese (*Stettiner Ent. Zeitg.*, LXXV, p. 219; 1914) from Biskra. However, this species is somewhat larger, the white bands of the tergites are somewhat narrower than in *wegelini*, and all across of about equal breadth, the clypeus is rugosely punctured, not shining in front, the thorax has some black hairs in its white pilosity, on tergite IV there is at base a transverse row of black hairs, segment V is in the middle more profusely clothed with black hairs, the cushion being therefore larger, and this segment is only at the sides white; the sternites show, besides the loose white marginal fringe, distinctly some brown hairs in the middle. The male of *cunicularia* has only a few black hairs on the thorax, but such hairs are distinctly intermixed in the white pile of the tergites III and IV; in general, the pilosity is somewhat longer, especially on the thorax, and has a slightly yellowish tinge; the posterior metatarsus is slightly curved. I have examined the types in the collection of the Berlin Museum (male, 27. i. 1894, female 16. ii. 1894).

Anthophora extricata spec. nov.

MALE : Length 9.5-11.5 mm. Black; antennal joint 1 beneath, labrum (with 2 black basal dots), clypeus in front and in the middle to base, frontal area, sides of frons (V-shaped as in *moricei*) and, as a rule, a small dot on the mandibles, yellow. Clypeus shining, in front sparingly set with coarse and fine punctures. Pilosity of the face long white, on the vertex with a yellow tinge, on orbits and vertex mixed with black hairs. Pilosity of the thorax long raised greyish-yellow, on account of the many black hairs among the white-yellow ones. Tergite I only with raised pale hairs, tergite II besides, with a transverse row of black hairs before apical margin, tergites III-V with more black than pale hairs. The white bands of the tergites are narrower than in *wegelini*, and are not distinctly broader in the middle than at the sides; the pale yellow apical margin of the segments is only on V visible, because on the anterior segments the margins are covered by the fasciae, as in *wegelini*. Femora with long raised hairs, hind tibiae with decumbent white hairs, becoming denser at the apex, interior face of the hind tibiae with mixed, vertically erect, hairs. Wings hyaline, veins black; cells little pubescent, only indistinctly so at the anterior margin of the wing. Nervulus about interstitial. Under side of the body clothed with white hairs. Antennal 3 fine, rather abruptly thickened at the apex, about three times as long as broad, longer than the two following, but distinctly shorter than the three following segments combined. Calcaria yellow. Tergite VII with two fine yellow teeth that are separated by a round excavation; the teeth are as slender as in *moricei*, finer and sharper than in *wegelini*.

Larger male specimens (f. *clavatipes* nov.) have somewhat more strongly enlarged hind femora and tibiae, but do not differ in any other character, to that I am not inclined to regard them as a separate species.

Female : Length 9-10 mm. Black, tarsal joints more or less paler. Pilosity in general yellowish-grey, on the under side of the body and the abdominal fasciae more whitish. The pale hairs of frons, sides of frons and vertex, and of the thorax too are profusely mixed with black hairs. On all abdominal tergites are black hairs visible among the white, though only few on tergite I; tergite V has white hairs only at the sides. The white or slightly yellowish-white bands of the tergites I-IV are narrow, narrower than in *wegelini*. Legs exteriorly greyish-yellow-white. Wings scarcely shaded, veins black, pubescence as in the male. Clypeus finely punctured and somewhat shining, as in *wegelini*. Antennal 3 fine, abruptly thickened at tip, well four times as long as broad, longer than the three, but somewhat shorter than the four following joints together. Tergite VI narrowly conical, somewhat shining, slightly convex in the middle, finely margined, not carinated.

Habitat : I know more than a dozen specimens of this species which I collected (February-April) in the Wadi Digla. There is a male specimen from Kosseir (February) in the coll. Ain Shams University, and one from Wadi Hof (March) in the collection of the Ministry of Agriculture.

In the male, this species differs from *A. wegelini* by the slenderer 3rd antennal joint, the partly dark pilosity along the whole orbits, the presence of black hairs in numbers on the thorax and the tergites, the narrower, evenly wide fasciae of the tergites, and the slight yellowish tinge of the hairs on thorax and abdomen. The female can be distinguished from that of *wegelini* by the narrower transverse bands of the abdomen, especially the yellowish tinge of the pilosity and in that the 3rd antennal joint is distinctly more slender; in the nuance of the coloration it equals *A. priesneri* which has, however, the clypeus dull, very densely and rugosely punctured and with a slight median carina, and has longer pilosity of the abdomen. *A. cunicularia* Fr. (from Biskra) is larger (11-12 mm.), its pilosity is grey (not yellowish-grey), the clypeus is densely rugosely punctured, it does not possess any black hairs on the tergites II and III, only IV showing near base a transverse row of long black hairs, antennal 3 is little longer than the three following joints together; only the venter is in the middle similarly set with black hairs, and only the marginal fringe being pale.

Anthophora moricei Friese

1899. *Anthophora moricei* Friese, *Ent. Nachrichten*, XXV, p. 322, (male and female).
1926. *Anthophora moricei* Alfken, *Senckenbergiana*, VIII, p. 101.

Male : Length 8-9 mm. Black, face pale yellow, blackenings much as in *wegelini*, the sides of the frons anteriorly somewhat more yellow and the mandibles black, seldom with the trace of a yellow dot. Pilosity as in *wegelini*, i.e. thorax and

vertex with only very few black hairs, and the abdomen in the typical form dorsally and ventrally without black hairs. The pale marginal fasciae of the tergites narrower than in *wegelini*. Calcaria yellow.

Antennal 3 much shorter than in *wegelini* or *extricata*, scarcely more than twice as long as broad. Puncturation of the tergites little dense but fine. The small teeth of the tergite VII are comparatively somewhat longer and more widely separated, by a rather *straight* interval.

FEMALE : Length 8-9.5 mm. Black with whitish pilosity below and above, on the vertex there are some black hairs also in the middle, and the thorax shows more black hairs than in *wegelini*. Abdomen with raised and decumbent white hairs, on tergite IV there are only a few black hairs intermixed, on V they are numerous. Tegulae testaceous to brown, margin paler.

Antennal 3 not quite three times as long as broad. Clypeus rather coarsely punctured, shining, medially convex lengthwise, but without keel, or a keel is indicated only in basal half. Nervulus almost interstitial. Cells m1, r1 and sc distinctly pubescent, at least at the fore margins.

I know specimens (from Wadi Digla, Kosseir) in which the tergites II and III too possess some black hairs between the normal white ones in front of the white fasciae. There is no other difference to be seen, especially the antennae are the same as in the many other specimens of the species I could examine. I think it advisable to give this form a name : var. *nigripilis* nov.

HABITAT : Common in the desert valleys and at the borders of the Arabian desert. X-IV. Also in Upper Egypt and in the Elba mountains.

A. moricei differs from all the species of this group by its smaller size and the considerably shorter, i.e. less elongate, antennal joint 3.

Anthophora priesneri Alfken

1916. *Anthophora* spec. near *calcarata* Storey, Min. Agric., Techn. Bull. 5, p. 18.
1932. *Anthophora priesneri* Alfken, *Mitteil. Dtsch. Ent. Ges.*, III, no. 8, pp. 122-124.

MALE : Length 9-11 mm. Black, tarsal joints 2-5 yellowish. Antennal joint 1 beneath, frons broadly V-shaped, frontal area, clypeus, labrum (with 2 dark basal spots) and mostly a dot on the mandibles, whitish; sides of the clypeus at the frontal suture to the mandibles with black line. Head covered with raised yellowish-white pilosity that is grey on the vertex, mixed with black hairs. Thorax clothed with raised yellowish-grey pilosity mixed with black hairs. Hairs on tergites I and II of the same colour but black hairs are only present on II towards the hind margin, while tergites III-VI bear chiefly black hairs; the hind margins show narrow adpressed dirty-white bands. Venter with long raised whitish-yellow hairs. Sides of body, femora and tibiae with raised pale pilosity too, on the hind tibiae it is decumbent and only at the hind margin towards apex somewhat denser and semi-erect. Calcaria yellow. Tegulae testaceous.

Genae short. Clypeus somewhat protruding, its puncturation fine and dense. Labrum very moderately transverse. Antennal joint 3 about three times as long as broad. The almost hyaline wings are distinctly pubescent at the fore margins of cells m1, r1 and sc. Veins black. Trochanters of hind legs with a hump, femora strongly enlarged, at the base with a broad blunt tooth, in the middle with a longitudinal carina that is convex in profile; hind tibiae much widened towards apex, with two sharp inferior edges, one of them ending in a long, pointed often pale tooth, the inner edge with a short small tooth at the apex. Lower face of the tibiae between the edges shining, sparingly punctured and setose. Tergite VII with two very short small pale teeth which are separated by a broad, straight interval.

FEMALE : Length 10.5-11 mm. Black, tarsal joints 2-5 ferruginous to brown. Pilosity of the body dirty-yellow-white, vertex and thorax with mixed pilosity, as in the male; tergite I with pale pilosity, tergite II mixed with longer black hairs, the pale hairs are somewhat plumose. Tergite V with black velvety cushion in the middle, VI not carinated, only finely margined along the sides, fasciae of the tergites are somewhat narrower than in *wegelini*. Hind tibiae and posterior metatarsus moderately densely set with rather long, semi-erect whitish-yellow hairs, venter at the sides with a loose white fringe, in the midde with shorter, ferruginous hairs. Calcaria yellow.

Clypeus dull, extremely densely rugosely punctured, median carina mostly visible, fine. Antennal 3 four times as long as broad, thickened at the apex, almost as long as the four following joints together. Pubescence of wing cells as in the male. Nervulus interstitial.

HABITAT : In the valleys of the Eastern Desert (Wadi Umm Assad, Wadi Digla, Wadi Hof, Wadi Rasheed, Wadi Abu Zoleiga, Wadi Gerawi; Sinai;Gebel Elba (October, January-April), probably during the whole winter). I found it hovering over *Stachys aegyptiaca*.

The female of the species differs at first sight from *wegelini* and *borgensis* by the not white or white-grey but yellowish-white-grey pilosity; from the former species, moreover, by the black hairs that are mixed with the pale ones, on the tergites, from the latter also by the denser pilosity of the tergites, and the adpressed pilosity of the fasciae which are loose and raised in *borgensis* which has black hairs on the sternites too and is a bit larger. The males cannot be confused with any other species on account of the structure of the hind legs. *A. moricei* (female) is much smaller, has considerably shorter antennal 3, and has shining clypeus.

Anthophora zanoni Grib. var. borgensis nov.

1925. cf. *Anthophora zanoni* Gribodo, *Boll. Mus. zool. Torino*, XXXIX, N.S. XVI, p. 15 (male).
1926. cf. *Anthophora zanoni* Gribodo, in Zanon, *Mem. Acc. Nuovi Lincei* (2) 8, p. 71.
1932. *Anthophora calcarata* Alfken (partim), *Mitt. Deutsche Ent. Ges.*, III, no. 8, p. 124.

MALE : 10.5-11.5 mm. Black, clypeus, labrum, antennal joint 1 beneath' yellow; clypeus dark at base and the sides so that there remains a broad yellow

median stripe and yellow fore margin, with a black line against the labrum; sides of frons with an upright flat yellow triangle, and frontal area narrowly transversely yellow; labrum yellow with large dark basal spots. Mandibles black. Face clothed with long white, laterally with black hairs, vertex with grey, i.e. mixed pilosity, like the thorax. Tergites I and II with grey-white raised hairs, III and following tergites with white and black hairs, under side with white hairs. Legs not very densely clothed with partly raised hairs, on the tibiae and metatarsi the dark ground remaining distinctly visible, hind margins and apices of tibiae and metatarsi with denser white pilosity, femora with white hairs. Tergites without pale fasciae. Calcaria yellow to brown, margined with black. Wings slightly shaded, veins black. Tegulae dark brown.

Antennal joint 3 thin, abruptly thickened at tip, well three times as long as broad, and about as long as the three following joints together. Hind femora enlarged, with a pointed tooth at base and a blunt flattened hump in the middle of the lower margin; hind tibiae inferiorly excavated lengthwise, shining, the exterior edge produced in a long very sharp tooth, the interior edge with a somewhat shorter tooth. Metatarsi slender, with reddish pilosity within. Wings distinctly pubescent in the cells m1, r1 and sc. Nervulus interstitial. Tergite VII with two short small teeth which are separated by a broad interval. Genae short, but visible.

FEMALE : Black. Face in the middle with grey-white, laterally with black hairs, also thorax and abdomen as in the male whereby tergites I and IV possess almost only white, the other tergites mixed, hairs. The raised pilosity of the abdomen is denser at the hind margins, but these hairs are not wholly attached, like in *desertorum*, but slightly raised. Tergite V with black hairs in the middle. The sternites show reddish hairs in the middle of or near the hind margins. Metatarsi exteriorly with somewhat raised whitish hairs.

Clypeus with coarse and rugose puncturation, *without* median carina. Antennal 3 rather abruptly thickened at tip, almost four times as long as broad, and about as long as the four following joints combined. Wings as in the male.

HABITAT : This species is known only from the northern coast (Alexandria, Dekheila, Borg-el-Arab), from February to March.

The male of *zanoni* is rather similar to *A. calcarata* Lep. which latter species has narrow fasciae of *decumbent* hairs on the tergites II - V, and in which the tergites II and following are predominantly black in their pubescence; the sides of the face are more distinctly V-shaped yellow, the basal femoral tooth is longer and the hump at the middle less conspicuous, in *calcarata*. The pilosity of the abdomen looks much less bristly, in *calcarata*. The female of *calcarata* is characterized by decumbent fasciae, and its clypeus is much more rugose in its puncturation than in *zanoni*. In *calcarata* all abdominal tergites are in front of the bands profusely clothed with black hairs, while in *zanoni* the 1st tergite shows no black hairs, the tergites II-IV much less black hairs, only those of tergite V being black. I had examined specimens of *A. calcarata* (from Algeria and Tunisia) identified by FRIESE. The

females of *A. desertorum* m. which had also been confused with *zanoni*, differ in having a medially smoothened clypeus, distinct fasciae of white decumbent hairs on the tergites and bare cell m1 of the fore wing; the pilosity of the tergites II and III is much shorter than in *zanoni*.

Our Egyptian form comes no doubt very close to *A. zanoni*, as described by GRIBODO (l.c.) from Libya, and is perhaps a race of it; it only differs by the white pile in the middle of the face, on the under side of the anterior body, and on the femora; according to GRIBODO, the head and the under side of *zanoni* are clothed with grey, the femora with black hairs. In the armature of the hind legs *borgensis* seems to agree with *zanoni*.

Group IV (blanda)

Anthophora blanda Pérez

1812. Unnamed, Savigny, Descr. Egypte, pl. I, fig. 10 (female).
1895. *Anthophora blanda* Pérez, Espèces nouvelles mellifères Barbarie, Bordeaux, p. 1 (male and female).
1897. *Podalirius blandus* Friese, Bienen Europas, III, p. 163.
1899. *Podalirius spinipes* Friese, *Ent. Nachrichten*, XXV, p. 321 (male and female).

MALE : Length 13-13.5 mm. Black, antennal joint 1 beneath, clypeus, sides of frons, frontal area, yellow; clypeus with dark median basal spot, besides, the base of the suture between clypeus and sides of frons blackened. Flagellum dark brown. Face with yellow, vertex, thorax and abdominal tergite I with raised ferruginous or yellow pilosity, without black hairs; tergites II-V with very narrow postero-marginal band of decumbent yellowish hairs, on the disk with *short* raised black hairs. Middle tibiae and metatarsus exteriorly with adpressed, at the margins with raised, white-yellow hairs, hind tibiae and metatarsus III exteriorly with decumbent and not very dense greyish-yellow hairs. Margins of the sternites with dense, semierect whitish pilosity.

Genae linear. Clypeus strongly protruding, labrum only moderately transverse, straight in front. Clypeus with fine dense, in the middle somewhat scarcer, punctuation. Antennal 3 rather abruptly thickened at tip, about three times as long as broad or a little more. Metatarsus II very slender. Trochanter III shortly triangularly produced, hind femora strongly enlarged, hind tibiae as well, the latter inferiorly with two longitudinal edges, the inner of which forming a blunt angle before apex and being excavated from this spot to the apex; the outer edge ending convex. Calcar short. Metatarsus III double-edged too, the inner edge straight and ending in a pointed tooth, that is separated from the tip of the metatarsus by a deep emargination. Terminal tarsal joint long. Tergite VII convex, with two converging carinae

towards apex, each of which terminating in a short point; the two points are separated by a roundish interval. Tegulae dark. Wings slightly shaded. Nervulus interstitial, cells with pubescence only at the fore margins of m1, r1 and sc.

FEMALE : Length 11-12 mm. Wholly black. Pilosity of head and thorax as in the male, sides of thorax and sternites whitish. The thorax has many black hairs between the pale ones. Tergite I clothed with white hairs at the sides, the white bands at the margins of the tergites II-IV narrow, but broadening towards the sides; tergite V only laterally with white hairs. Hind tibiae and metatarsi exteriorly with rather coarse, white to yellow-white pilosity. The tergites show on the disks (of II and following) a *very short* raised black pilosity.

Clypeus convex, slightly protruding, with dense, somewhat rugose puncturation, without distinct median keel. Antennal 3 somewhat more than three times as long as broad, almost as long as the four following joints together, its apex not so abruptly thickened.

HABITAT : Uncommon; Cairo, Marg, Kafr el-Dems, Assiout. March-April.

The types of FRIESE'S *A. spinipes* (male, Cairo, 13. iii. 1899; female, Cairo, 4. iv. 1899) of the Berlin Museum are exactly identical with the specimens of our collections, of *A. blanda* Pér., identified by ALFKEN.

Group V (lutulenta)

Anthophora lutulenta (Klug)

1845. *Saropoda lutulenta* Klug, Symb. phys., Dec. 5, Ins., pl. 50, fig. 5 (female).
1897. *Podalirius lutulentus* Friese, Bienen Europas, III, p. 107.
1926. *Anthophora tenella* Alfken (nec Klug), *Senckenbergiana*, VIII, p. 101.

MALE : Length 8.5-9.5 mm. Black, fore tarsi brown, joints 2-4 and base of 5 of the middle and hind tarsi yellow. Antennal joint 1 beneath and face very pale yellow (but not white), tips of mandibles reddish. Flagellum brown below. Face clothed with raised white, head below with long white, thorax with raised white, hairs, having a yellowish tinge, as well as the 1st tergite of the abdomen; the following tergites are black at base and have narrow, yellowish - white or dirty-white bands; the tergites II-IV show in front of the bands laterally slightly raised pale hairs, and, besides, tergite II possesses some pale raised hairs on the disk. Sternites with whitish fringe, sternite IV in the middle broadly velvety ferruginous. Tibiae and tarsi exteriorly clothed with adpressed whitish hairs, below with longer white hairs; on the metatarsus III the ground is visible under the pilosity, and there are, in addition, single slightly raised hairs present; *interiorly* the metatarsus is clothed with *ferruginous* hairs. Joint 5 of the middle tarsi shows a distinct brush of black hairs. Wings as in the female. Calcaria yellow.

Labrum almost as long as broad, clypeus slightly protruding, in the middle with a slight about triangular callosity but without keels, puncturation weak, shallow. Antennal 3 about 1.5 times as long as broad, 4 transverse, much shorter than 5. Tergite VII yellowish, carinated lengthwise, produced into two broad triangles that are separated by an irregular arch or a distinct angular excision.

FEMALE : 9-9.5 mm. Width of head 3.6-3.8 mm. Black, tarsal joints 2-4 and base of 5 testaceous to brown. Flagellum of antennae beneath ferruginous to brown. Face whitish-yellow, i.e. labrum, mandibles (tips brown), clypeus and frontal area; sides of frons black; clypeus either with only very small basal spots or with slightly larger spots which are angular within, though they never occupy more than half of the length of the clypeus. Head with short white raised pilosity, thorax as well but with a slight yellowish tinge; black hairs are wanting or only singly present about the scutellar base. Tergite I with raised and attached grey-yellowish-white hairs, the following tergites similar in colour but II and III without, raised hairs; however, there is a fine black transverse band (sometimes also on tergite I) present across the middle of these segments; slightly raised hairs are scarce, especially on the penultimate tergites; the apical margin of the Vth tergite shows a slight velvety cushion of ferruginous to brown hairs in the middle, and not a transverse row of hairs, as in *fayoumensis*. Sternites, particularly the apical ones, with white fringe and hairs. Middle tibiae predominantly with decumbent, hind tibiae and metatarsus III exteriorly with slightly raised, whitish hairs, interiorly with yellowish to ferruginous hairs. Tegulae yellow. Wings hyaline, veins yellow at base, brown towards apex (about from stigma onwards).

Labrum somewhat transverse, coarsely sculptured, with indistinct median carina. Clypeus finely and densely punctured, but in some cases the puncturation fused to longitudinal wrinkles; there is no smooth keel visible but a slight convexity along the middle. Antennal 3 about twice as long as broad or slightly less, 4 and 5 transverse, 3 somewhat shorter than the three following joints together. Cells of wing very indistinctly pubescent near fore margin of cells m1 and r1. Nervulus interstitial.

HABITAT : Not rare (Borgash, El-Mallah, Mansuriah, Kerdasa, Abu Rowash, Wadi Umm Assad, Wadi El-Tih, El-Saff), February-May.

A certain variability noticeable in this species might indicate that we have do deal with different very similar species; especially the form having somewhat longitudinally rugose clypeus and some black hairs on the thorax. Perhaps the female of *A. helouanensis* is hidden among the others. But all these doubts can only be dispersed when more material will be available. In any case, *A. lutulenta* is an interesting subject for further investigations.

ALFKEN held this species to be *A. tenella* Klug. However, if one compares with the two figures given by KLUG : *lutulenta* (fig. 5) and *tenella* (fig. 6) it becomes clear that only the species having a distinct dark transverse line on the tergites II (and III) and having an interstitial nervulus agrees with *lutulenta*. KLUG gives the

sizes as being equal in both species (9 mm.), but from the illustration it appears that the head of *tenella* is smaller than that of *lutulenta*. The examination of Klug's type, which I owe to the courtesy of Dr. STEINBACH of the Berlin Museum, shows that the species described above is the true *lutulenta*, and is not *tenella* (q.v.).

Anthophora helouanensis spec. nov.

MALE : Length 9 mm. Width of head 3.6 mm. Black, tarsal joints 2-4 and base of 5 ferruginous, flagellum beneath brown, not ferruginous; antennal 1 beneath, the whole face (labrum, mandibles, clypeus, frontal area and sides of frons) pale yellow, tips of mandibles reddish. Wings hyaline, veins brown except those on extreme base which are testaceous; cell m1 distinctly pubescent at the fore margin, r1 and sc scarcely so. The short raised pilosity of the face whitish, of the vertex yellow-white, of the thorax and tergite I raised and yellowish-grey, without black hairs; the following tergites with black pilosity, and I-VI with narrow white postero-marginal bands on yellowish segmental margins; tergite II distinctly loosely set with raised white hairs, the following tergites sparingly set with short such hairs. Middle and hind tibiae exteriorly with decumbent whitish hairs, below with raised such hairs; metatarsus III exteriorly little densely, at the margins more densely, clothed with decumbent whitish hairs, with some semierect pale hairs, *interiorly with yellowish-white pilosity*. Calcaria yellow. Sternites III and IV transversely in the middle with a yellowish velvety tomentum, fringed at the margins, VI emarginated in the middle. Tegulae ferruginous.

Genae not developed. Labrum slightly transverse, anteriorly somewhat broader than at base, i.e. slightly trapezoidal, shining, with moderately coarse, shallow puncturation. Clypeus not protruding, with slight dorsal convexity and medially rather dense, laterally less dense, puncturation, shining. Antennal 3 short, nearly 1.5 times as long as broad, 4 little transverse, 5 and following joints somewhat longer than broad. Puncturation of the abdominal tergites very dense, the punctures like being pricked in from behind. Tarsal joint 5 of mid legs distinctly enlarged but without black hairs, bare. Nervulus interstitial or slightly postfurcal. Tergite VII dark, above with grey-white pilosity, broadly conical in shape and with median carina; at the apex with bluntly triangular broad teeth that are separated by an obtusely angled excision.

HABITAT : 1 male, Helouan (1. iv. 1938), leg. H. PRIESNER.

This male is similar to that of *lutulenta*, but lacks the brush hairs on tarsal joing 5 of the mid legs, has a white (not ferruginous) pilosity of the inner face of the 3rd metatarsus, and has by an obtuse excision more widely separated, blunt teeth of tergite VII. It is possible that the yet unknown female of this species is one of those questionable varieties of *lutulenta*.

Anthophora elbana spec. nov.

MALE : Length 8.5-9.5 mm. Black, joints 2-4 and base of 5 of middle and hind tarsi ochrous. Antennal joint 1 beneath, the whole face (frontal area, sides of frons, clypeus, labrum and mandibles), ivory-white (not yellow). Flagellum dark. Wings hyaline, costa and veins at base ochrous. Clypeus and sides of face densely clothed with white hairs so that the ground is almost covered. Thorax with raised white, and tergite I laterally with such pilosity, tergites I-IV with narrow white postero-marginal bands upon yellowish transparent margins; in front of the fasciae, i.e. on the disk, the tergites are clothed with black but also with grey decumbent hairs almost everywhere, though tergite II shows a few long raised white hairs too. Middle and hind tibiae and middle tarsi exteriorly with decumbent white hairs, the posterior metatarsus *exteriorly and interiorly with black* pilosity. Joint 5 of middle tarsi with a conspicuous disk-like brush of black hairs. Tegulae ochrous.

Labrum transverse. Clypeus distinctly somewhat protruding, finely and densely punctured, the puncturation, though, almost covered by the pile. Antennal joint 3 short, scarcely longer than broad, although the antennae appear to be long. Nervulus indistinctly prefurcal, practically interstitial. Hind legs without any special characters. Tergite VII with a sharp median carina, clothed with white hairs, teeth very short, slightly triangularly protruding, the excision little deep, about of the shape of a brace.

FEMALE unknown.

HABITAT : 2 males, Gebel Elba, Wadi Aideb (February-March). Holotype in the collection of the Ministry of Agriculture, paratype in the author's collection.

Among the small species having a conspicuous tarsal brush in the male sex this species differs from *fayoumensis* by the strongly protruding non-carinated clypeus the more whitish pilosity, the coloration of the hairs on the 3rd metatarsus, the shape of the apical margin of tergite VII and also by its larger size. *A. alfkenella* is similar too, but differs in having *white* face, much less transverse labrum and yellowish pile of the thorax.

Anthophora fayoumensis spec. nov.

MALE : Length 7.5-8.5 mm. Black, the whole face yellow, only the tips of the mandibles brownish, antennal 1 yellow beneath, dark above, joints 2 and 3 brown, flagellum ferruginous. Tarsal joints 2-4 and base of 5 testaceous. Hind margins of tergites yellowish transparent beneath the pilosity. Wings hyaline with for the major part yellowish veins. Pilosity of the body yellow to ferruginous, the thorax without black hairs. Abdomen with decumbent posteromarginal fasciae on tergites I-VI of pale yellow to ferruginous colour; these bands do not contrast much, since the tergites show a yellowish adpressed, not very dense, pilosity in front of the bands too; only tergite II bears a few raised pale hairs which can be seen in

profile. Middle and hind tibiae exteriorly clothed with decumbent yellow hairs, metatarsi at the margins with densely, on the face with sparingly, set pale hairs; interiorly the metatarsi bear ferruginous to reddish hairs. Calcaria yellow.

Labrum and clypeus shining, sparingly and shallowly punctured, the former with fore margin raised and with a smooth median carina so that on both sides of the disk a shallow fovea is formed. The sides of the clypeus are separated from the base of the mandibles by the sides of the frons. Antennal joint 3 short, little longer than broad. Tegulae testaceous. Wing cells of fore margin with some pubescence in front; nervulus interstitial. Puncturation of the tergites dense and somewhat rough. Tergite VII produced into two yellow broad teeth that are separated by a triangular excision; dorsum carinated lengthwise. Apical joint of middle tarsi somewhat enlarged, with some black hairs but without a distinct brush. Hind tibiae pubescent at the inferior face too, not smooth and shining (cf. *concinna*), and without tooth at the lower apex.

FEMALE : Length 8-8.5 mm. Width of head at most 3.5 mm. — Black, face yellow as in the male but sides of frons and a *small* spot at the sides attached to the clypeal suture, black; the clypeus is therefore at base as broadly yellow as the width of the frontal area. Antennae black, flagellum from joint 4, beneath or partly also above, ferruginous. Pilosity of the face white, not very dense, of vertex, thorax and abdomen more yellowish-white, on the vertex raised, on the thorax and the base of the 1st tergite of the abdomen short and raised; rest of tergite I and following tergites with *very dense* decumbent pubescence so that the marginal bands are not at all contrasting from the disk, but appear somewhat yellow owing to the yellow apical margins; in some cases the 2nd tergite shows an indistinct fine transverse dark line, though this is never so conspicuous as in *concinna* or *lutulenta*; the middle of the 5th tergite bears ferruginous hairs at the hind margin which are, however, not raised cushion-like, as in *lutulenta*. Calcaria yellow. Hind tibiae and tarsi exteriorly not quite densely clothed with whitish hairs, middle tibiae with such decumbent hairs; posterior metatarsus interiorly with yellow or ferruginous (not dark) hairs. Wings as in the male. Margins of sternites yellowish transparent, with yellowish fringe.

Clypeus and labrum densely punctured, dull to slightly shining, the callosities of the male wanting or faintly indicated. Antennal 3 about twice as long as broad.

HABITAT : Everywhere in Middle and Upper Egypt (Cairo, Maassara, Helouan, Beni Suef, Assiout; Wadi Nama (South eastern desert); Siwa. March-May. Types in coll. Min. Agric. (Cairo).

This common species is in the female sex rather similar to *lutulenta*, but easily distinguished by the smaller size, the nearly uniformly greyish pubescence of the tergites, and the invariably ferruginous colour of the marignal fringe of tergite V in the middle. The male is characterized by the greyish-yellow colour of the pile, the clypeal foveae and the distinctly *yellow* face. The species comes nearest to *mellina* sp. n., but possesses a brush of hairs on tarsal joint 5 of the mid legs, the pale pubescence on the disk of the segments, not the marginal bands only, and the more strongly

transverse labrum which is not produced in the middle of the fore margin, as this is the case in *mellina*. Male specimens from the Oasis Kharga are somewhat larger than those of the Nile valley or the Eastern Desert, so that the head reaches almost a width of 3.5 mm, and the hairs of the hind tibiae are a little longer. However, I cannot find any specific differences. Females were confused by Alfken with *humilis* Alfken = *tenella* Klug (q.v.).

Anthophora shagrensis spec. nov.

FEMALE : 8.5-9 mm. Width of head 3.5-3.6 mm. - Black, legs usually dark brown, hind margins of the sternites reddish; antennae ferruginous beneath, from segment 4 onwards; labrum and mandibles (tips dark), frontal area (narrow, transverse) and clypeus yellow; the latter with large black spots that are fused at base with the sides of the frons and occupy about half of the clypeus' length, leaving a yellow median line that is slightly widened at the base, and occupies about one-sixth of the width of the frons; the design is about the same as in the male of *A. pipiens*. Pilosity of the frons not very dense, whitish, short and raised; vertex with yellow hairs, mixed with black ones, thorax yellowish-grey with black, propodeum at the sides more whitish. Tergite I in front rather sparingly set with whitish hairs, the following tergites densely clothed with grey-yellow decumbent hairs; on tergite II (or also I) a transverse ill-defined black stripe about as in *lutulenta*; middle of tergite V with dark brown cushion; marginal bands are not distinctly separated, only noticeable because they lie on the paler hind margins of the tergites, like in *lutulenta*. Sternites with yellowish fringe only. Middle tibiae and metatarsus II with decumbent yellowish-white, hind tibiae and metatarsus III with slightly raised coarser whitish, hairs; the hind femora show an apical hair-spot of adpressed pilosity; metatarsus III interiorly with ferruginous to rusty hairs. Tegulae shining, ferruginous. Wings hyaline, slightly pubescent only in cell r 1; veins brown, paler at base, costa testaceous. Nervulus interstitial.

Clypeus shining, densely punctured, with fine somewhat smoothened median line and fore margin. Labrum slightly transverse. Antennal 3 scarcely twice as long as broad, about as long as the three following joints together, or slightly shorter.

MALE unknown.

HABITAT : I know 3 females from the Wadi Shagra (types) and 1 female from the Wadi Assiouti (April, August), collected by Moh. KASSIM (coll. Min. Agric.); M. TEWFIK found 2 females of this species in the Wadi El-Lega (Sinai).

The species comes closest to *lutulenta*, is scarcely smaller, has somewhat larger dark spots of the clypeus which is smoothened along the middle and in front, and has a considerable quantity of black hairs on the vertex and the thorax, between the yellowish hairs, and the flagellum is pale ferruginous. The yet unknown male has most likely also bicoloured pilosity of the thorax and a pale flagellum.

Anthophora tenella (Klug)

1845. *Saropoda tenella* Klug, Symb. phys., pl. 50, fig. 6 (female).
Anthophora humilis Alfken (in schedis) nec Spin.

FEMALE : Length 7.5-8.5 mm. Width of head somewhat less than 3.5 mm. Black, tarsal joints (2-) 3-5 brownish or testaceous, flagellum ferruginous beneath. Labrum, base of mandibles (tips brownish or reddish) and clypeus in front *pale* yellow; the dark basal portion of the clypeus occupies half or slightly more of its length; sides of face dark, clypeus with pale fine median line, and mostly also the frontal area as a fine pale transverse line. Head and thorax with dense whitish pilosity (or on the latter with slight yellowish tinge) but without black hairs or only single such hairs in front of the scutellum. Tergite I with raised, the following tergites with decumbent grey hairs, tergite II with a few pale raised hairs which are on the following tergites much shorter and semi-erect. Tergite V in the middle with a velvety black cushion of short hairs. Under side of thorax and sternites at the sides with whitish, the latter in the middle with more ferruginous hairs. Hind tibiae and metatarsi exteriorly with loose white or yellowish-white, metatarsus III interiorly with ferruginous to pale brown hairs. Tegulae yellow. Wings hyaline, veins yellow at base, becoming brownish towards tip of wing. Calcaria yellow.

Labrum transverse, but less so than in *nivosella*. Puncturation of the clypeus dense and fine, somewhat longitudinally rugose; without carina. Antennal 3 short, about 2.5 times as long as broad, somewhat shorter than the three following joints together, joints 4 and 5 transverse. Nervulus only very slightly prefurcal, less so than in *nivosella*.

MALE : Length 6.7-7 mm. Black, tarsal joints 2-4 and base of 5 ferruginous to brown, flagellum of antennae ferruginous beneath; antennal 1 beneath, the whole face and the mandibles, whitish. Face clothed with very dense and long slightly raised silvery-white hairs; vertex, thorax and tergite I with raised pale grey-white pilosity, without black hairs; tergite II and following segments with rather dense decumbent pilosity and with (profile) long raised white hairs that become scarcer on tergites III and IV. The white pilosity is at the margins somewhat denser so that ill-limited bands appear, in rubbed specimens the margins of the tergites are pale. Under side and legs with long white pilosity, the sternites with short white fringe. Hind tibiae and tarsi exteriorly with adpressed white hairs, the metatarsi bear interiorly testaceous hairs. Calcaria yellow. Veins of fore wing yellowish about in basal half.

Clypeus protruding, puncturation not visible. Labrum moderately transverse, almost smooth. Genae indistinct. Antennae rather long, but joint 3 only as long as broad, 4 square, joints 9-11 distinctly longer than broad. Wings without noticeable pubescence, nervulus interstitial or slightly prefurcal, as in the female. Terminal joint of middle tarsi slightly thickened, without black hairs. Tergite VII with white

pubescence above, with a fine median keel, at the apex with two rather broad small teeth that are separated by an arched or slightly wavy emargination; between the teeth one notices on each side of the keel 2 small black tubercles, in obliquely dorsal view.

HABITAT : Original locality is Sakkara ; I saw specimens from Mansuriah, El-Mallah, Borgash, Kafr Hakeem, Nahia, Abu Rowaṣh, Cairo, Wadi Digla, Wadi Umm-Assad, Meadi and Helouan (March-May).

Specimens of this species were identified by ALFKEN with *humilis* Spin.; ALFKEN'S *tenella* is identical with *lutulenta* Klug. SPINOLA'S *A. humilis* cannot be identical with *tenella* Kl. as it has black antennae and wing veins. Through the kindness of Dr. STEINBACK of the Berlin Museum I was able to examine KLUG'S type specimen which I found fully agreeing with the species described above. The specimen has a length of 8 mm. (not 9 mm. as given by KLUG) because the head is in an unnaturally horizontal position in the unique mount.

Anthophora humilis (Spinola) (?)

1838. *Saropoda humilis* Spinola, *Ann. soc. ent. France*, VII, p. 544 (female).

FEMALE : Length 8-8.5 mm., width of head 3.2-3.3 mm. - Black, tarsal joints 2-4 and base of 5 ferruginous. Flagellum of antennae dark. Labrum, base of mandibles, fore margin and a very fine median line of the clypeus, the latter sometimes slightly widened at base, whitish-yellow; the black base of the clypeus is emarginated on both sides of its fore margin; frontal area dark. Face clothed with moderately long grey-white hairs, about as in *shagrensis*, less dense than in *tridentella*. Thorax with grey pilosity, mixed with black hairs, but less strongly so than in *shagrensis*. Tergite I with raised whitish, tergite II with few raised white hairs, this and the following tergites otherwise with dense decumbent mouse-grey pilosity; the margins of the segments are not yellowish transparent, only very narrowly brownish; tergite V at the middle with black velvety cushion. Sternites laterally with some grey, otherwise with grey-brownish fringe, sternite V with somewhat longer white-grey, horizontal hairs. Tibiae and metatarsi exteriorly clothed with not quite decumbent whitish, metatarsus III interiorly with dark brown hairs. Wings hyaline, veins dark, somewhat pubescent only in cell m 1 near fore margin and in cell r 1. Tegulae testaceous.

Labrum transverse, coarsely rugosely punctured. Clypeus very densely punctured, the fine yellow median line slightly raised, smooth. Antennal 3 about twice as long as broad, 4 strongly, 5 less transverse, 6-11 about square. Puncturation of the thorax dense and rasp-like. Nervulus interstitial,

HABITAT : 1 female, Abukeer, 10. iv. 55, coll. Ain Shams University; 1 female, Mamoura, 9. iv. 31, coll. Min. Agric.

This is one of the uniformly coloured small species and is, by the pattern of the clypeus and the interstitial nervulus, coming closest to *tridentella*, *shagrensis* and *selecta*; *A. tridentella* differs by the strongly transverse labrum, the denser pilosity of the face, the not quite evenly grey pilosity of the abdomen and the pale wing veins; *shagrensis* by the latter character, the great number of black hairs on the thorax, the pale flagellum and yellow frontal area, the broader median line of the clypeus, the dark transverse line on tergite II and the interiorly ferruginous pilosity of the metatarsus III; *selecta* has the white-yellow colour of the clypeus confined to a narrow fore margin, and the clypeus finely punctured everywhere, also in the middle. All these species are, besides, specifically different by the pale transparent margins of the tergites. The species seems to be confined to the northern coast and is certainly not common. — Male unknown.

It is the only species known to me that agrees with the description given by SPINOLA.

Anthophora selecta spec. nov.

FEMALE : Length 8-8.5 mm., width of head 3.3-3.4 mm. - Black, tarsal joints 2-5 ferruginous. Antennae dark, flagellum beneath slightly reddish towards apex. Labrum, a basal spot of the mandibles (which are brownish, tip dark) and the fore margin of the clypeus, yellow; this yellow fore margin is narrow in the middle and abruptly widened at the sides; frontal area and sides of frons black. Face with not very long and dense, laterally almost decumbent, medially somewhat raised whitish pilosity. Vertex and thorax clothed with whitish-yellow pilosity, thorax with many black hairs among the pale ones. Tergite I with moderately long hairs like the thorax, but with only quite few black hairs; the following tergites densely clothed with decumbent grey hairs, and with only very few short pale raised hairs on tergite II and semi-erect pale hairs on the penultimate tergites, as this is the case in other species of this group. The pilosity is upon the fine yellowish transparent posterior margins of the tergites somewhat denser so that fine and indistinct bands appear; tergite V with a black velvet-cushion in the middle. Sides of thorax and underside with whitish, sternites of the abdomen with a poor white fringe at the sides and ferruginous hairs in the middle. Tibiae and metatarsi exteriorly with semi-adpressed whitish hairs, metatarsus III interiorly with brown hairs. Tegulae yellowish. Wing veins testaceous in basal half, dark about in apical half. Some microsetulae can be noticed in cells r 1 and sc. Calcaria yellow.

Labrum transverse, dull. Clypeus with dense fine somewhat rugose punctuation. Antennal 3 short, well 2-2.5 times as long as broad, almost as long as the three following joints together, 4 and 5 distinctly transverse. Puncturation of the thorax very dense, granulose, of the tergites extremely fine and dense, somewhat transversely rugose. Nervulus interstitial.

HABITAT : 1 female (holotype), Borgash, 18. iv. 1934 (Min. Agric.).

Of the small species having an interstitial nervulus, *A. alfkenella* differs especially by its sharply defined fasciae of the abdomen and the white (not yellow) face; *A. shagrensis* by the medially yellow clypeus, the ferruginous flagellum, and the interiorly pale ferruginous pilosity of the 3rd metatarsus; *A. tridentella* by the dense white pile of the face, the yellow-white median stripe of the clypeus and the uniformly grey-white thorax; *A. humilis* has no yellowish tint of the hair-covering, a yellow line of the clypeus, dark veins and dark hairs on the interior face of the 3rd metatarsus.

Anthophora fallaciosa spec. nov.

MALE : Length 7.6-8 mm. Width of head not quite 3 mm. Black, tarsal joints 2-5 testaceous, tip of 5 darkened. Flagellum ferruginous below. Antennal joint 1 below and the whole face *yellow* (now white-yellow), without dark markings, tips of mandibles reddish. Veins of the hyaline wing testaceous in basal half, dark in apical half of wing. Tergite VII at the margin, i.e. its triangular tips, testaceous. Frons clothed with little dense yellowish-white, vertex, thorax and abdominal tergite I with raised yellow (perhaps even ferruginous), hairs, tergites II-VI with short, semi-erect, black hairs, tergite II in addition with single raised whitish hairs, visible in profile; tergites I-VI with *very narrow* whitish posteromarginal fasciae of decumbent hairs. Tibiae with adpressed dirty-white, at the hind margin and apex with raised white hairs; metatarsus III exteriorly with scattered decumbent whitish hairs so that the dark ground remains visible throughout; interiorly is the metatarsus III clothed with blackbrown, in certain directions appearing dark red-brown, hairs. Joint 5 of middle tarsi thickened, at the sides with semiattached black hairs. Wings with pubescence noticeable only in cell r 1. Nervulus interstitial. Calcaria yellow. Tegulae yellow.

Labrum slightly transverse, fore margin forming a very flat blunt angle, surface shining, very scarcely punctured. Clypeus distinctly convex in the middle but without keel, puncturation fine,moderately dense. Antennal joint 3 short, about 1.5 times as long as broad, 4 about square, the following joints somewhat longer than broad. Puncturation of the head within the upper angles of the eyes very fine and dense, dull. Thorax very densely punctured, dull. Tergites of the abdomen densely punctured, slightly shining. Tergite VII carinate medially, posteriorly with two *broad* triangular ferruginous teeth that are separated by a triangular incision, the sides of this incision being very slightly concave.

HABITAT : 1 male, Amriah in April (leg. and coll. H. PRIESNER).

This species comes close to *A. perlustrata*, but the latter has shorter antennal joint 3, distinctly transverse joint 4, dark clypeal basal spots, darker tergite VII with slenderer teeth, interiorly paler pilosity of the 3rd metatarsus and broader fasciae of the tergites; *A. mellina* is at once distinguished by the carinated clypeus,

somewhat broader fasciae and broader head; *alfkenella* has a white face, black tergite VII and blunter, smaller triangular teeth, dark antennae and veins, and some raised black pilosity of tergite II.

Anthophora perlustrata spec. nov.

MALE : Length 8 mm. Width of head 3.2-3.3 mm. Black, tarsal joints 2-4 and base of 5 yellowish; mandibles red-brown with large pale yellow basal spot and blackish base; face pale yellow, i.e. clypeus, labrum, sides of frons and frontal area; suture between sides of frons and clypeus with a small black longitudinal spot; antennal 1 yellow beneath, flagellum brownish not ferruginous. Face clothed with long yellow-white, vertex with yellow, thorax above and at the sides and tergite I with yellow to ferruginous raised hairs, without black hairs. Tergites II-IV (-V) with single raised pale hairs, else with black decumbent hairs on the disk; postero-marginal bands narrow, on the anterior tergites grey-yellow, otherwise grey. Legs exteriorly clothed with grey-white adpressed hairs, metatarsus III interiorly with ferruginous to brown hairs. Under side of anterior body with raised grey-white hairs, sternites only at the sides with horizontal white fringe, in the middle nearly bare, sternites IV and V dull on account of a velvety dark brown tomentum. Tegulae testaceous. Wings hyaline, veins at base testaceous, distally dark. Cells scarcely pubescent. Nervulus interstitial. Calcaria yellow.

Labrum transverse, slightly arched in front. Clypeus shining too, without calli, puncturation owing to the dense pile not visible. Antennal 3 short, very little longer than broad, 4 much shorter than 5 or 6. Middle tarsi with a distinct but not very long brush of black hairs. Tergite VII with median keel, at the sides apically with two short teeth that are separated by an almost *straight* interval which bears at the hind margin 2 very small tubercles (cf. *tenella*).

HABITAT : 1 male (holotype), Taloun, 18.iv.1927 (coll. ALFIERI).

In spite of the differently formed VIIth tergite this species comes in the *lutulenta* group, since it agrees in many other characters with the other species of this group. *A. lutulenta* and *elbana* are larger, grey species, having triangular teeth separated by an angular excision, or by a brace-shaped one, respectively, and both show some grey pilosity in front of the fasciae; *A. alfkenella* differs by its white face and the coloration of the hind legs, etc.

Anthophora tridentella spec. nov.

MALE : Length 7.5-8 mm. Width of head 3.3-3.4 mm. Black, base of tarsal joints 2-5 pale yellow. Margins of tergites yellowish transparent. Antennal joint 1 beneath and the whole face whitish yellow, mandibles with brown tips. Flagellum scarcely paler below, never ferruginous. Face with long snow-white, vertex, thorax

and tergite I with raised grey-white pilosity, without black hairs. The tergites show narrow bands of decumbent white hairs, and they bear also in front of the bands whitish but less densely set hairs; raised white hairs are present but very short, only on tergite II somewhat longer; the decumbent pilosity of the disks of the tergites becomes somewhat denser towards the apex of the abdomen. Under side of anterior body with raised white hairs, the sternites only at the sides with a pale fringe, in the middle with fine ferruginous tomentum, sternite V more broadly with very fine black-brown tomentum. Femora with long raised hairs, middle and hind tibiae with decumbent white pilosity, metatarsi exteriorly with scarce (ground visible), at the hind margin with denser, white pilosity, the metatarsus III interiorly with paler or darker brown hairs. Calcaria yellow. Tegulae testaceous. Wings hyaline, veins yellow, only distally somewhat brownish.

Labrum *strongly transverse*, almost straight in front, smooth, almost without puncturation. Clypeus very finely and densely punctured, without keels. Antennal 3 not longer than broad. Nervulus slightly prefurcal. Tergite VII with a median keel and *three small apical teeth* the central of which representing the tip of the median carina, and being sometimes shorter and blunter than the lateral teeth.

Female : Length 7.5-8 mm. Width of head less than 3.5 mm. Black, tarsi brownish. Face black, only labrum, mandibles (with red tips) and the fore margin of the clypeus, yellowish-white; the pale margin of the clypeus occupies at most half of its length, usually less, and a fine median line never reaches the base or is absent. Antennae black, flagellum beneath at most brownish, never ferruginous. Pilosity of the face rather dense, whitish to whitish-yellow; the body above clothed with whitish-grey-yellow, thorax without or with only very few dark, hairs. Abdomen clothed with adpressed grey hairs, and the posteromarginal bands do not contrast much, only by the fact that the margins have the chitin transparent; a very scarce raised pilosity is only noticeable on tergite II in profile. Tergite V with a black cushion in the middle. Sides of the sternites slightly fringed with whitish-yellow, in the middle with red-brown hairs. Hind tibiae and metatarsus III with slightly raised white-yellow pilosity, the latter interiorly with dark brown hairs.

Sculpture of labrum and clypeus not well visible owing to the dense pilosity. Antennal 3 about only twice as long as broad, somewhat longer than the two following joints together, joint 4 strongly transverse.

Habitat : There is a series of specimens in the collection of the Ministry of Agriculture, from the Wadi Assiouti (2. iv. 1917); a male from the Suez Road(iii); 2 females from Siwa (iv) and 1 female in the collection of the Ain Shams University, from Kom Osheem (iv).

In the male sex this species is easily distinguished from all small species by the three small teeth of the VIIth tergite. The female was confused with *tenella* Kl. (*humilis* Alfken); however, the dark antennae, the darker clypeus, the yet visible abdominal fasciae, the dark pilosity of the inner face of the hind metatarsus and the darker pilosity of the middle of the sternites, readily distinguish *tridentella* from

tenella. *A. fayoumensis* has a yellow face and frontal area, the former with only very small basal spots of the clypeus, pale flagellum, pale hairs interiorly on the hind metatarsus and less strongly transverse labrum.

Anthophora mellina spec. nov.

MALE : 8-9.5 mm. Black, tarsal joints 2-4 and base of 5 ochrous. Antennal joint I beneath and the whole face lemon-yellow, joint 2 and base of 3 dark, rest of flagellum ferruginous below. Face with white-yellow, vertex, thorax and tergite I of abdomen with raised ferruginous (in older specimens yellow), pilosity; the postero-marginal bands of the tergites narrow, consisting of adpressed ferruginous hairs; in front of the bands there are no adpressed pale hairs, i.e. the disks are dark except for some single raised pale hairs on tergite II. Wings hyaline, veins dark, yellow towards base. Under side of body with yellowish pilosity. Tibiae and tarsi with decumbent ferruginous pilosity.

Labrum scarcely transverse, slightly produced in front at middle, but without foveola, very little punctured, shining. Clypeus not protruding, not very densely punctured, with fore margin and median line raised, and therefore with broad, shallow foveae as in *fayoumensis*. Antennal 3 short, though somewhat longer than broad, the penultimate joints almost twice as long as broad. Thorax with very dense and rough, abdomen with fine, puncturation. Tergite VII with a fine sharp median carina and ending in two yellow triangular teeth which are separated by a triangular excision. Hind tibiae on the under side smooth and shining at base only, whereas more than the apical half is punctured and pilose; the inferior angle shows a very short, usually under the pile completely concealed, dark small tooth which is easily overlooked. Calcaria yellow. Apical joint of tarsi II only slightly thickened, and only with decumbent short dark hairs, without brush. Tegulae ochrous to ferruginous. Wings only in the cells of the fore margin slightly pubescent. Nervulus interstitial or very little postfurcal.

FEMALE : 8-8.5 mm. Black, tarsal joints 2-4 (-5) and flagellum of antennae from joints 4 or 5 onwards, ferruginous. Base of clypeus for about half of its length black, rest and a narrow frontal area and a median line, yellow; margin of the black base of the clypeus bisinuate. Face little dense whitish-yellow, thorax and abdomen with pale yellowish-grey pilosity, thorax without black hairs; abdomen only on tergite I with long, on the remaining tergites with evenly decumbent, pilosity; tergite V in the middle of the hind margin with ferruginous hairs; tibiae clothed with adpressed and tarsi with semidecumbent whitish hairs, exteriorly. Sternites very finely and not very densely punctured, shining, fringe hairs short, pale, margins of segments yellowish transparent. Wings hyaline, veins pale at base, darkened towards apex.

Labrum broader than long, coarsely rugosely punctured. Clypeus finely and rather densely punctured. Antennal 3 about twice as long as broad, 4 transverse,

5 about square; 3 somewhat longer than the two, shorter than the three, following joints combined. Nervulus very slightly postfurcal.

HABITAT : I took this species at Meadi, Wadi Digla and Wadi Hof (v, vi); in the collection of the Ministry of Agriculture there is a male from the Bahr-el-Ghazâl (v).

By the keels and foveae of the clypeus the male is similar to *A. fayoumensis* but has no brush on the 5th tarsal joint of the mid legs, and the disks of the tergites are dark, without pale decumbent hairs in front of the fasciae; *A. concinna* also possesses a brush, like *fayoumensis*, and differs from *mellina* by its simple clypeus, shorter antennae, broader abdominal fasciae, a conspicuous pale tooth at the apex of the hind tibiae which are triangular in cross-section, a.s.o. The female comes nearest to *fayoumensis* but is readily distinguished by the large black clypeal spots that occupy at least the basal half; *A. tenella* has large spots too, but they are rounded interiorly, not angular, and the pale colour of the fore margin is ivory-white, the 5th tergite has a black cushion, and the nervulus is slightly prefurcal rather than postfurcal; in *A. tridentella* the pilosity of the face is very dense white and the abdomen shows slightly indicated marginal fasciae, the flagellum is not ferruginous, the frontal area is dark and the middle of tergite V bears a black cushion; *A. shagrensis* is larger, has mixed pilosity of the thorax, bears a dark cross-line on tergite II, a.s.o.

ALFKEN identified the *mellina* males of my collection with *concinna* Klug, though the description and figure given by KLUG are against this interpretation.

Anthophora concinna (Klug)

1845. *Megilla concinna* Klug, Symb. phys., Dec. 5, Ins. pl. 49, fig. 11 (male).
1897. *Podalirius concinnus* Friese, Bienen Europas, III, p. 104.
1899. *Podalirius tridentatus* Friese, *Ent. Nachrichten*, XXV, p. 322 (male).

MALE : Length 6-8 mm. Black, tarsal joints 2-4 yellowish. Face, antennal joint 1 beneath, mandibles (tips dark) and labrum pale yellow; flagellum ferruginous below. Pilosity of face whitish to yellow, not dense, of thorax yellowish-brown to ferruginous, raised, like that of base of tergite I; no black hairs on the thorax. The tergites show only dark hairs in front of the fasciae, the latter being broad, ferruginous, and reaching at the sides almost to fore margin; the hairs of the under side of head and thorax are whitish to grey. Middle and hind tibiae and metatarsus II exteriorly clothed with decumbent golden-yellow hairs, the posterior metatarsus exteriorly and interiorly with dark, nearly black hairs, only at the extreme base and apical margin with reddish-brown hairs. Wings hyaline, veins at base testaceous.

Clypeus, in lateral aspect, little protruding, shining, the surface without keels, the puncturation of the sides not dense, the *fore margin shows two small foveae so that three blunt indistinct teeth are formed.* Labrum transverse, shining. Antennae

comparatively short (flagellum length 2.5 mm.), joint 3 short, scarcely longer than broad. Tegulae ferruginous. Wing cells very little pubescent near fore margin of wing. Nervulus practically interstitial, though very slightly prefurcal. Joint 5 of middle tarsi distinctly thickened with a conspicuous brush of black hairs. Hind tibiae widened towards apex, about triangular in cross-section, with its inner surface smooth and shining, and a short pale tooth at the apex. Calcaria of middle tibiae dark, of hind tibiae at least margined with brown. Tergite VII conical, sides straight, apical margin triangularly incised so that 2 triangular teeth are formed; the tergite is longitudinally carinated too.

FEMALE : Length 8-8.5 mm. Black, face yellow, i.e. labrum, mandibles (with dark tips), a transverse frontal area and the clypeus; the latter usually wholly yellow or shows a quite indistinct lateral dot; sides of frons dark. Flagellum ferruginous below. Pilosity of the thorax as in the male, only at the scutellar base there may be a few black hairs. Abdomen with *ochrous* decumbent pilosity, tergites I-III (or only one or two of them) on disk with a more or less fine transverse black line; tergite V in the middle of the hind margin with brown to black-brown hairs; margins of the sternites with whitish fringe. Pilosity of the legs as in the male, posterior metatarsus exteriorly with grey-yellow, interiorly with brown hairs. On the spots where the hairs of the abdomen are rubbed off the margins of the segments are yellowish transparent.

HABITAT : Not rare, from the following localities; Abu Roash, Kerdasa El-Mallah, Pyramids of Giza, Cairo, Meadi, Helouan; Assiout, Assouan. (March June).

In the collection of the Ministry of Agriculture there are specimens from Hedjas (Jedda, February, 1937, leg. M. KASSIM) in which the male has the calcaria entirely yellow, and the metatarsus III exteriorly some pale hairs at base; the female shows none or only on tergite II a fine black transverse line, and its tergite V has pale brown to ferruginous hairs at the hind margin : var. (ssp. ?) *hegasica* nov.

A. concinna could only be confused in the female sex with *A. fayoumensis*; this species has, however, the nervulus clearly interstitial or slightly postfurcal, the 3rd metatarsus with pale brown or ferruginous hairs interiorly, grey (not yellow) pilosity of the abdomen without black cross-lines, and no black hairs on the thorax; tergite V has pale brown to ferruginous hairs at the hind margin, and the calcaria are all yellow. The males of *fayoumensis* cannot be confused, as their hind tibiae have the inner face not smooth and shining and have no apical tooth, and the tergites II and III always bear some pale hairs in front of the marginal fasciae too. *A. fayoumensis* and *A. mellina* have in the male, as against *concinna*, a distinctly sculptured clypeus, i.e. smooth and raised fore margin and median keel; the female of *mellina* is uniformly clothed with yellow-grey hairs on the abdomen and has large dark spots on the clypeus.

A. lutulenta Alfken (*Senckenbergiana*, VIII, p. 101; 1926), nec *lutulenta* Klug, might be identical with *concinna*.

Anthophora alfkenella spec. nov.

MALE : 8-9 mm. Black, middle and hind tarsi but sometimes only basal half of joint 5, ferruginous. The whole face *white*, only the tips of the mandibles and 2 small dots at the base of the labrum dark. Antennal joint 1 white beneath. Face with raised white to yellow-white, vertex, thorax and abdominal tergite I with raised yellow to ferruginous hairs, without black hairs; tergites I-VI with *narrow* white apical fasciae of decumbent hairs, tergite II, besides, with some raised pale hairs, tergites III-V with shorter raised black hairs, visible in profile. Head and thorax beneath clothed with white or grey, abdominal sternites at the sides with white, in the middle with black, hairs, some of them having white tips. Middle and hind tibiae with adpressed white hairs that do not wholly cover the dark ground, the margins and tips with some longer white hairs; metatarsus III exteriorly and interiorly clothed with black hairs, exteriorly with single white hairs, at the apex, exteriorly with a small white hair-spot. Joint 5 of middle tarsi with conspicuous black brush.

Clypeus not protruding, shining, with a slight convexity in the middle where it is densely punctured, while the sides are less densely and more strongly punctured. Labrum transverse. The apex of the sides of the frons does not reach the mandibles. Antennal joint 3 short, little longer than broad. Tegulae testaceous. Wings hyaline, cells m 1 and sc at the fore margin, and cell r 1 pubescent. Nervulus interstitial or slightly postfurcal. Tergite VII carinated lengthwise, at the apex with two broad triangular teeth that are separated by an angular excision.

FEMALE : Length 9-9.5 mm. Width of head 3.6-3.7 mm. Body, inclusive of antennae and tarsi, black. Face *white*, i.e. anterior half of clypeus, a fine median line and, connected with it, a transverse frontal area (forming a white T), the labrum and mandibles, the latter with dark tips. Pilosity as in the male but the vertex somewhat, the thorax profusely, mixed with black hairs; tergite I almost only with pale pilosity; the single raised hairs on tergite II yet shorter than in the male; the tergites II and III show at the base, not only at the hind margin, some greyish decumbent pilosity so that a black cross-band appears; tergite V in the middle with black hairs only. Hind tibiae and metatarsus III exteriorly with somewhat loose dirty-white, interiorly with black, hairs. Sternites largely fringed with black, only laterally with a few white, hairs. Calcaria yellow.

Clypeus strongly punctured with fine smooth median line. Antennae comparatively short. Antennal 3 short, gradually widened towards apex, about 2.5 times as long as broad and about as long as the three following joints together.

HABITAT : Mex, Abukeer (iv). Types in the collection of the Ain Shams University.

Because of the structure of tergite VII of the male and its tarsal brush of the middle legs this species comes in the *lutulenta*-group and is characterized by the black inside of the tibiae and tarsi, the dark antennae, the black pile of the sternites

and the white face; *A. elbana* has longer, decumbent pilosity of the face, more strongly transverse labrum, yellow face and much less excavated tergite VII. The female is from the species around *albigena* at once distinguished by the interstitial nervulus, from *lutulenta* by the large clypeus-spots, and the dark hairs of the metatarsus and the sternites. The abdomen of *alfkenella* is more flattened than in the other species of the *lutulenta*-group; habitually it reminds somewhat of *A. fulvodimidiata* but differs by its much smaller size, the white face and the paler pile of the outer face of the hind tibiae.

Anthophora fulvodimidiata Dours

1869. *Anthophora fulvodimidiata* Dours, Mon. icon. Anthoph., p. 181 (male).
1879. *Anthophora nigripes* Pérez, Actes soc. Linn. Bordeaux, XXXIII, p. 142 (female); teste Friese.
1897. *Podalirius fulvodimidiatus* Friese, Bienen Europas, III, p. 97.

Male : Length 9-10 mm. Black; clypeus, frontal area, sides of frons, labrum, a large basal spot of the mandibles and antennal joint 1 beneath, yellowish-white. Flagellum somewhat brownish below. Face with not very dense white, vertex with more yellowish, pilosity, like the thorax and tergite I in front. Abdomen with moderately broad fasciae of yellowish white colour, on tergites I-VI, and only a few white decumbent hairs in front of the bands; the disks otherwise with decumbent and extremely short raised black pilosity. Tibiae exteriorly and interiorly with black, only at the exterior edge and the apical margins with whitish-grey, hairs; metatarsus II only at base with white hairs, metatarsus III wholly black. Calcaria dark.

Clypeus slightly protruding, slightly shining, its puncturation dense in the middle, less so at the sides. Apices of sides of frons (triangles) not reaching base of mandibles. Labrum transverse. Antennae comparatively short, joint 3 not quite twice as long as broad. Wings very slightly shaded,veins black, pubescence noticeable in cells m 1, r 1 and sc, near fore margin. Tarsi II on joint 5 with a weak brush of black hairs. Hind tibiae widened towards apex, with two lower edges, the space between them smooth and bare, strongly shining; at the apex of the lower edge there is a black pointed tooth. Puncturation of the tergites very dense, rough, nearly granulated. Tergite VII with two almost triangular teeth which are reddish at tips and separated by a triangular incision.

Female : Length 10.5-11 mm. Black, face ivory-yellow, clypeus with two basal spots that are emarginated in front and therefore pointed at the interior fore angle; the pale median line is broad, the frontal area linear, not triangular; sides of frons dark, mandibles at base and labrum pale. Face with short yellowish, vertex and thorax with short yellow-brown, raised pilosity, mixed with black hairs especially at the base of the scutellum and before. The bands of the tergites mostly yellowish, wholly decumbent, tergite II though chiefly black, with some fine pruinose pale hairs across base, too; fascia of tergite IV white, pilosity of tergite V black. Sternites fringed with black hairs, only the sides of tergite IV show some white fringe hairs.

Wings as in the male. Hind tibiae and tarsi clothed with black hairs, only at the exterior margin of the former sometimes some white hairs. Antennal 3 only 2.5 times as long as broad.

HABITAT : In numbers in July-September, Mersa Matrouh, leg. Dr. T. SAYED (coll. Ain Shams University); Mariout.

Anthophora galalensis spec. nov.

FEMALE : Length 11-11.5 mm. Width of thorax about 4.6 mm. Black, legs black-brown, tarsal joints 2-5 testaceous to pale brown. Clypeus in front and labrum yellow, the former with 2 moderately large dark basal spots that are fused with the black sides of the frons. Mandibles yellow, tips dark. Wings hyaline, veins dark. Flagellum ferruginous beneath. Pilosity of clypeus rather dense whitish, on vertex, thorax whitish with slightly yellowish tinge, and very few black hairs, particularly at the scutellar base. The abdomen is covered with *very dense wholly decumbent grey hairs*, only on tergite I at the sides with somewhat raised and longer ones than elsewhere; the middle of the Vth tergite possesses a black pilose transverse cushion spot. Under side everywhere with pale hairs, the sternites with fairly short white fringe. Middle tibiae densely clothed with white decumbent, metatarsi all along with slightly raised, white hairs; hind tibiae and metatarsus III with semi-erect white hairs so that the ground becomes visible, interiorly with brown hairs. Calcaria pale yellow. Tegulae pale ochrous.

Clypeus slightly protruding, puncturation owing to the dense pile not visible, labrum coarsely rugose. Genae not developed. Antennal joint 3 about three times as long as broad and about as long as the three following joints together. Nervulus decidedly interstitial. Wing cells practically bare.

MALE unknown.

HABITAT : Of this characteristic species I only know one perfect female from the Wadi El-Gararyat, North Galala, 21-25. iii. 1935 (leg. FARAG, coll. Ministry of Agriculture).

Among the species having wholly, evenly and densely grey pubescence of the abdomen, *galalensis* is characterised by the size, the yellow calcaria and the interstitial nervulus and cannot be mistaken with any other one described herein.

Group VI (inclyta)

Anthophora semirufa (Friese)

1898. *Podalirius semirufus* Friese, *Termesz. Füzetek*, XXI, p. 308.
1930. *Anthophora fulviscopa* Alfken, *Stettiner Ent. Zeitg.*, XCI, p. 226 (female).

MALE : Length 13-14 mm. Black, only the margins of the tergites slightly reddish transparent. Face pale yellow, clypeus without black suture lines. Mandibles

with large pale basal spot, antennal joint 1 pale yellow beneath. Flagellum dark. Pilosity of face short, white, of vertex, thorax and abdominal tergite I, short, more or less dark ferruginous, without black hairs. Under side of thorax somewhat paler, with pale yellow to white hairs; tergites II-III of abdomen with short, nearly decumbent, the following tergites with short, raised black hairs. Middle and hind tibiae clothed with black hairs, the middle tibiae exteriorly also with some ferruginous hairs.

Clypeus densely punctured. Genae not developed. Antennal joint 3 three to four times as long as broad, distinctly widened at the apex, about as long as the three following joints combined. Tegulae ferruginous. Wings distinctly shaded, cells distinctly pubescent. Nervulus interstitial. Metatarsus III laterally flattened, curved, with a curved groove at the inferior margin and a preapical rounded bulge or hump at the inferior margin; distinctly set with black hairs at the base, but bare at the lower margin towards apex. Tergite VII in the middle of the apex rounded, at the sides with two acute reddish teeth so that, as a whole, three projections are visible, the median of which being broad and rounded. Margins of sternites with dark raised pilosity.

FEMALE : Length 14-15 mm. Black, clypeus in front with short brown, vertex, frons, thorax and abdominal tergite I, as well as the sides of the hind tibiae and 3rd metatarsus, with ferruginous pilosity, that of the thorax short. Tergites II and III clothed with short decumbent, the following tergites with short raised black pilosity. The whole under side and the fore and mid legs clothed with black hairs.

Clypeus coarsely and rugosely punctured, with median carina. Antennal joint 3 gradually thickened towards tip, three to three and a half times as long as broad, and about as long as the three following joints together. Wings distinctly infumated.

HABITAT : I saw the species from the following localities : Helouan,Wadi Digla, Wadi Hof, Wadi Rasheed, Wadi Abu Handal, Wadi Hussein (April-July).

Anthophora oraniensis Lep.

1841. *Anthophora oraniensis* Lepeletier, Hist. nat. Ins. Hym., II, p. 39 (female)
1846. *Anthophora oraniensis* Lucas, Expl. sci. Algérie, Zool. III, p. 143, pl. 1, fig. 1.
1897. *Podalirius oraniensis* Friese, Bienen Europas, III, p. 96.

FEMALE : Length 15-16 mm. Black, the whole face and the temples with white, vertex, thorax and abdominal tergite I with short-cut red pilosity; tergites II-VI with short, adpressed and scarcer raised, *black* pilosity; tergites II-IV each with a full, snow-white, very narrow fascia of adpressed hairs, tergite V at the sides like IV with some longer white hairs. Under side and legs clothed with black hairs, sides of sternites with white hairs. Fore and middle tibiae exteriorly with some white decumbent hairs, *hind tibiae with a triangular longitudinal spot of white hairs.* Meta-

tarsus III with black hairs only. Tegulae brown to black-brown, finely punctured. Wings somewhat infumated, veins black.

Clypeus strongly convex but without carina, very finely and rugosely punctured. Antennal joint 3 slender, abruptly thickened at tip, about three times as long as broad, little longer than the three following joints together. Posterior metatarsus comparatively broad and short. Pubescence of wing cells in m 1 and r 1 conspicuous, in sc only in the basal corner. Puncturation of the tergites very fine. Plate of tergite VI dull. Genae linear.

MALE : Unknown to me; but according to LEPELETIER characterized in having antennal joint 1 whitish yellow in front, and sides of frons, clypeus and mandibles of the same colour. Thorax clothed with whitish hairs below, as well as the tibiae and tarsi above. Segment V like the preceeding ones, segment VI like V of female. Everything else as in the female.

HABITAT : I only know two specimens from Egypt : 1 female, Dekheila, 18. ii. 1919 (coll. ALFIERI); 1 female, Mex, 19. ii. 1919, leg. C.B. WILLIAMS (coll. Min. Agric.).

Anthophora inclyta Walker

1871. *Anthophora inclyta* Walker, List Hym. Egypt, p. 98 (female).
1897. *Podalirius inclytus* Friese, Bienen Europas, III, p. 298.

MALE : 16-17 mm. Black, legs black, antennal joint 1 beneath and the whole face yellow, mandibles dark in apical half. Frons and vertex mostly with pale yellow, the whole remaining body ferruginous or yellow to dirty yellow (old specimens) pilosity. Hairs of the abdomen decumbent. Tibiae exteriorly clothed with adpressed yellow to testaceous hairs, the metatarsus III exteriorly much less densely, at the margins and apex more densely pilose. Under side with white or grey hairs.

Clypeus rather flattened, finely and densely punctured, labrum large, broader in front than at base, slightly tranverse, with more scattered and shallow punctures, shining. Antennal joint 3 more than three times as long as broad. Wings distinctly shaded with dark nervures; pubescent in cells m1, m3, r1-r3 and sc. Nervulus interstitial. Metatarsus III with an obtusely angled widening below. Median plate of tergite VII narrowed towards apex and rounded there where it is ferruginous, at the sides it shows two yellowish teeth situated at a lower level than the median portion which is more strongly protruding.

FEMALE : Length 16-17 mm. Black, the legs and sternites may be red-brown. The whole body clothed with ferruginous pilosity, on the sides of the face it may be paler. The hairs of the thorax and abdominal tergite I are shortly cut, on the remaining tergites the ferruginous pilosity is dense and adpressed, tergite IV showing in addition some raised ferruginous hairs, tergite V a ferruginous median cushion, and at the sides longer hairs of the same colour. Fringe of sternites ferruginous, too.

Tibiae and tarsi evenly clothed with ferruginous hairs, the interior faces with dark-brown to blackish hairs. Tegulae pale. Wings as in the male.

Frons and clypeus flattened, very finely rugosely punctured. Labrum transverse. Genae extremely short. Antennal 3 gradually thickened towards tip, about four times as long as broad, longer than the three but somewhat shorter than the four following joints together. Thorax not punctured but with a very dense shallow granulation. Tergites very finely and shallowly punctured. Hind tibiae and metatarsus III broad.

HABITAT : A southern species. Red Sea coast, Wadi Ambaga (near Kosseir); Gebel Elba (Wadi Aideb, W. Kansisrob); Sinai (iii-v).

NOTE : *Anthophora fulvitecta* Kirby (*Bull. Liverpool Mus.*, III, p. 22) is most likely identical with *inclyta* Walker.

Anthophora alternans (Klug)

1845. *Megilla alternans* Klug, Symb. phys., Dec. 5, Ins. pl. 50, fig. 3 (female).
1897. *Podalirius alternans* Friese, Bienen Europas, III, p. 65.
1899. *Podalirius wegeneri* Friese, *Ent. Nachrichten*, XXV, p. 321 (male and female).
1926. *Anthophora alternans* (*wagneri*) Alfken *Senckenbergiana*, VIII, p, 114.

MALE : Length 12-15 mm. Black, face white, without black markings, with large almost hexagonal white frontal area and a white antennal joint 1, beneath; flagellum reddish below. Face with short, white, thorax with white-grey to yellowish-grey hairs, with some intermixed black hairs. Tergite I clothed with pale raised hairs, tergites II-V on the disk with decumbent black pilosity, and only a few semi-erect short black hairs between, and each segment with a fairly broad white apical band. Middle tibiae at the hind margin with a comb of long white hairs, metatarsus II with scattered, at the hind margin with longer, white hairs; hind tibiae exteriorly with only adpressed densely set hairs, like the metatarsus III and the joints 2-4. Tegulae testaceous. Wings with veins somewhat brownish at base, cells nearly bare, only r 1 a little pubescent. Nervulus interstitial.

Clypeus somewhat protruding, convex, dull, scarcely punctured; the whitish frontal triangles (between eye and apex of clypeus) produced in a fine tip, and therefore attaining extreme apex of clypeus. Labrum transverse, emarginated in front. Genae not developed. Antennal 3 short, not quite twice as long as broad. Tergite VII tridentate, the median tooth bluntly triangular, the lateral teeth slender, pointed, the apices of these three productions are about on the same level. Hind tibiae curved, with vertically raised black hairs at the anterior margin, which only occupy the basal two-thirds or three-fourths of its length.

FEMALE : Length 13.5-15 mm. Black, face dull white, densely and finely punctured, with two black basal spots fused with the sides of the frons, the spots being not angular within but *evenly rounded*, i.e. the white median stripe of the clypeus

being concave on both sides. Frontal area little white. Face with short white, vertex with yellowish, thorax with grey-yellow to nearly ferruginous, hairs; black hairs are present among the pale ones about the middle of the thorax. Tergite I clothed with moderately long but densely set white to yellow hairs, tergites II-IV at the hind margin with adpressed white hairs forming broad fasciae (broader at the sides), bases of the tergites narrowly balck; tergite V only with black hairs; raised pale and dark hairs are sparingly present on tergite IV. Tibiae and tarsi almost or wholly with adpressed grey-white hairs, the parallel-sided metatarsus III exteriorly also almost for all its length (or three-fourths) clothed with grey-white hairs. Head and thorax beneath with grey, abdominal sternites with dark hairs.

Antennal joint 3 about 2.5 times as long as broad, gradually thickened towards apex, and about as long as the three following joints together. Veins dark, pubescence as in the male.

HABITAT : Uncommon (Taloun, Borgash, Sakkara, Fayoum), April, May.

The female of this species, rightly recognized by ALFKEN, is at first sight rather similar to *klugi* (q.v.), but at once distinguished by the rounded clypear spots which are angular in *klugi*, by the broader fasciae, the wholly black tergite V and the interstitial nervulus. The male is from exteriorly similar forms of group VII easily separated by the structure of tergite VII and the curved hind tibiae. *A. boops* has narrower frons, inferiorly dentate metatarsus III, and the lateral teeth of tergite VII slightly pushed towards base in comparison with the blunter median tooth.

Of 5 specimens in the Vienna Museum labeled "wegeneri Typus" by FRIESE, one belongs to *alternans*, the remaining 4 are *klugi* (*farinosa* Alfken nec Klug). A male specimen in the same collection, identified with *alternans* by FRIESE, is *crocea* Klug (sic !), a female (from Luxor) is *mucorea* Kl. True specimens (males and females) are in the accessions of the above collection (from Fayoum, leg. SCHMIEDEKNECHT), unidentified.

ALFKEN puts *A. wagneri* Friese as a synonym to *alternans*. It is to be assumed that *A. wagneri* is a "lapsus mentis aut calami" ALFKEN's and in this case the synonymy is correct.

Anthophora boops Alfken

1926. *Anthophora boops* Alfken, *Senckenbergiana*, VIII, pp. 100, 115 (male).

MALE : Length 13.5-15.5 mm. Black, flagellum black, face white, without dark spots or stripes, frontal area forming a high (not flat) triangle, antennal joint 1 white beneath. Face with shorter, vertex with longer, grey-white hairs, thorax with very short grey-white pilosity, without black hairs. Tergites of the abdomen with white marginal fasciae that are complete on tergites I-IV, narrow and linear in the middle on V, and broadly interrupted in the middle on VI. Tergite VII clothed with

black hairs. Under side of head and thorax with white, abdominal sternites with black hairs. Tibiae and metatarsi clothed exteriorly with decumbent white hairs, middle tibiae with a row of long raised white hairs posteriorly; metatarsus III for the major part with black hairs but also with white adpressed hairs at the exterior edge.

Clypeus not protruding, densely and finely punctured, shining. Face comparatively narrow, much narrower than in either *alternans* or *klugi*, eyes large. Labrum almost as long as broad. Frontal triangles terminating far from apex of clypeus. Antennal joint 3 about three times as long as broad. Tegulae punctured and pubescent, brownish. Wings hyaline, veins dark, costa paler, cells scarcely pubescent, only r 1 somewhat so. Nervulus interstitial. Metatarsus III beneath produced in a blunt angle, the lower edge of the metatarsus from base to tooth straight, from tooth to apex concave. Tergite VII, as a whole, tripartite, having a median lobe representing the median tooth of *A. alternans* but being broader, and flanked by a lateral small triangular tooth on either side; the median lobe surpassing the lateral teeth.

FEMALE : unknown (see my remarks sub *A. vidua*).

HABITAT : Mansuriah, Kafr Hakeem, Kerdasa, Abu Rowash, Giza, Samalout and Wadi Gerawi (April-June).

Anthophora vidua (Klug)

1845. *Megilla vidua* Klug, Symb. phys., Dec. 5, Ins. pl. 49, fig. 10 (female).
1897. *Podalirius bicinctus viduus* Friese, Bienen Europas, III, p. 101.
1916. *Anthophora bicincta* var. *vidua* Storey, Min. Agr., Techn. Bull., 5, p. 18.

FEMALE : Length 16-18 mm. Black, sternites mostly dark reddish brown. The whole body with black pilosity except a full white fascia on hind margin of tergite I and sometimes a broadly interrupted one on II, composed of easily rubbed off decumbent hairs; the remaining tergites with adpressed black pilosity, only the apical tergites with slightly raised black hairs. Thorax with short raised black hairs. All legs with black hairs. Genae wanting. Clypeus rather finely and densely punctured, somewhat rugose, with a fine smooth median line. Frons comparatively narrow, much less than twice as broad as one eye, the inner orbits evenly rounded (in most *Anthophora* spp. the eyes above on the vertex more strongly convex than below where they touch the mandibles). Antennal joint 3 gradually thickened towards tip, about 3.5 times as long as broad. Wings slightly, in old specimens strongly, shaded with brown, only with cells near fore margin of wing somewhat pubescent. Nervulus interstitial.

HABITAT : Mansuriah, Kafr Hakeem, Kerdasa, Giza Pyramids, Dashour; Marg, Wadi Gerawi, Samalout; Ikingi (Mariout).

Although this species is represented in numbers in the local collections (Min. Agric., Ent. Soc., ALFIERI) there are only females present. The labels show that

they were collected at least on three occasions together with *A. boops* of which the above collections contain males only. *A. vidua* and *A. boops* were found together on 6.v. 1914 near the Giza Pyramids, on 27. v. 1918 at Samalout and on 10. v. 1927 in the Wadi Gerawi. At the Pyramids and at Samalout no other *Anthophora* spp. were collected on the days concerned. I am of the opinion that the two forms are the sexes of *one* species, though the differences between them are quite unusual for this genus (7). The two insects have rather little in common, but they belong in one group and their comparatively narrow frons is also a common character. Up to the present there is no definite proof yet for their specific identity.

Anthophora concolor Alfken

1926. *Anthophora concolor* Alfken, *Senckenbergiana*, VIII, p. 119 (female).

Following a translation of the description (in German) given by ALFKEN: "Female : 14 mm. Black. Mandibles in the middle somewhat reddish transparent. Genae not noticeable. Labrum very coarsely rugose and with raised black pilosity, the punctures here and there, particularly along the median line, fused to longitudinal wrinkles, the extreme fore margin being smooth. Frontal area rather coarsely punctured. Frons evenly finely and densely punctured, like sides and vertex with raised black pilosity. Antennal 3 somewhat longer than the three following joints together. Mesonotum dull, evenly and rather strongly punctured. Scutellum slightly shining, with somewhat scarcer puncturation than the mesonotum. Postscutellum with long raised pilosity. Median area of the propodeum dull with deep median sulcus; in the middle of basal half without sculpture or pile, at the sides coarsely punctured and with raised pilosity. Tergites of the abdomen without raised hairs, evenly and finely punctured, tergite V red-brown transparent, with velvet-black cushion at the posterior margin. Plate of tergite VI long and slender, shallowly margined at tip, grey shining, microscopically punctured and chagreened. Sternites irregularly punctured, with densely set fringe hairs at the hind margin, here and there red-brown transparent, sternite VI with apex somewhat shining. Legs black, the terminal tarsal joints red-brown. Scopa of tibiae and pedicellus black, calcar of hind tibiae red-brown at tip. Wings slightly shaded, veins black, tegulae black".

"A uniformly black species being, on superficial examination, similar to the black forms of *A. retusa* L. and *A. acervorum* L. but differing by the lack of the pilosity on the tergites, the black tibial scopa and the different puncturation. From *A. fumipennis*, being uniformly black too, it may easily be distinguished by the little shaded and not metallic blue fore wings".

HABITAT : 1 female, Egypt (no locality mentioned), leg. A. ANDRES.

(7) Extraordinary dimorphism of sex is known in other Apidae (e.g. *Xylocopa aestuans* L., *Bombus argillaceus* Scop., *Dasypoda argentata* Panz., *Chalicodoma* spp., a.o.).

Anthophora maculigera spec. nov.

1812. Unnamed, Savigny, Descr. d'Egypte, pl. I, fig. 11 (male).

MALE : 13.5-16 mm. Ground colour black; the whole face, antennal joint 1 beneath and base of mandibles, white; flagellum dark. Face with only short and not dense white pilosity. Thorax and abdominal tergite I with short-cut yellowish grey hairs which are more white at the sides of the propodeum and the hind margin of tergite I; the remaining tergites are black, II and III with wholly decumbent, the other tergites with very short raised black hairs; the sides of the tergites II-III(-IV) show at the hind margin narrow white fasciae of adpressed hairs, which are *broadly* interrupted in the middle. Exterior faces of the middle and hind tibiae and tarsi clothed with decumbent silvery-grey or grey hairs. Pubescence of the sternites short, not white. Fore tarsi exteriorly with long white hairs; middle and hind tibiae interiorly with raised hairs. Head, thorax and femora below with grey-white hairs.

Clypeus densely, at the sides more coarsely, punctured. Genae not developed. Antennal joint 3 gradually widened towards apex, somewhat more than twice as long as broad. Tegulae blackish, finely punctured and partly pubescent. Wings only in front of the cells near the fore margin and in the r cells somewhat pubescent, discal cells bare. Nervulus interstitial. Metatarsus III with a blunt tooth behind middle that is narrower than in *A. semirufa*. Tergite VII similarly formed as in *semirufa*, median plate slender, conical, without distinct impression or marginal sulcus, rounded at the apex, and on each side of the shorter lateral teeth separated by a circular excision.

FEMALE unknown.

HABITAT : Hitherto from the northern coast only: Dabaa, Hammam (May); on 20.v.1928, 16 specimens were collected by FERRANTE (coll. Ent. Soc. Egypt).

This is another species the female of which is supposed to be an entirely black one (cf. *concolor* Alfken), though we have to compare also with *A. festae* Grib. (Cyrenaica), another *Paramegilla*-like form of which the female only is known. In this species the 1st and 2nd tergites are clothed with grey hairs, and the sternites have a white lateral fringe of white hairs; it is smaller too, on an average (12-14 mm.), and we have to expect its male to be distinctly smaller than *A. maculigera*. For these reasons I cannot hold *A. maculigera* to be the male of *A. festae*.

Anthophora nubica Lep.

1841. *Anthophora nubica* Lepeletier, Hist. nat. Ins. Hym., II, p. 33 (male).
1845. *Megilla nubica* Klug, Symb. phys. Dec. 5, Ins., pl. 49, fig. 8 (male) and 9 (female).
1869. *Anthophora nubica* Dours, Mon. icon. Anthophora, p. 85.
1897. *Podalirius nubicus* Friese, Bienen Europas, III, p. 100 (male, female).

Original description (from Latin) : "Male : 16-17 mm. - Black; antennae below ferruginous from joint 4 to tip, labrum (a dot at the sides of the base black),

clypeus (a nearly semicircular spot at the sides of the base and the basal margin black), sides of face, a triangular spot above the clypeus" (= frontal area) "and the broad base of the mandibles white; vertex and thoracic dorsum with white pilosity and intermixed black hairs; sides and under side with white pilosity. Abdomen on segments I-III nearly bare, sparingly black pilose, IV-VI with dense decumbent white fasciae at the sides, the two ultimate segments and the sides of the anus with raised black hairs; sternites at the sides with white, in the middle hardly with black, fringe. Legs with black hairs, fore legs above with white hairs, on the mid legs the tibiae only above with white hairs, on the hind legs above only with a white spot at the base of the tibiae, the metatarsus with long black pilosity. Wings somewhat shaded, veins dark, margin blackish".

FEMALE : Length 17-18.5 mm. Black; labrum, clypeus at the fore margin and an anteriorly somewhat widened narrow median line, then a triangular frontal area, white. Clypeus coarsely but unevenly set with larger and smaller punctures. Flagellum brownish below. 3rd antennal fairly evenly widened towards apex, 3.5 to 4 times as long as broad. Head in front with white pilosity that is mixed with black hairs on the vertex. Thorax with short, nearly grey-blue pilosity, white hairs being largely mixed with black ones. Propodeum and under side more or less long and densely clothed with snow-white hairs. Tergites with adpressed black pilosity, tergite IV wholly, V at the sides, with snow-white decumbent pilosity. Sternites at the sides with adpressed white tufts of hairs. Fore tibiae and tarsi, middle tibiae exteriorly, with white, hind tibiae and tarsi with raised black pilosity, hind tibiae at the base with a white hair-spot. Wings strongly infuscated, the cells everywhere densely pubescent. Nervulus prefurcal.

Described after 1 female, Gebel Elba, Wadi Aideb, February (leg. H. PRIESNER, coll. Min. Agric.).

Anthophora fumipennis Alfken

1926. *Anthophora fumipennis* Alfken, *Senckenbergiana*, VIII, p. 120 (female).

Following a translation of the description given by ALFKEN :

FEMALE : Length 19 mm. Genae linear, ferruginous. Labrum with decumbent black, in the middle and at base bristly, exteriorly all around with velvety, pilosity. Mandibles with testaceous spot at tip. Clypeus with rather dense, coarsely rugose puncturation, with slight median keel and narrowly smooth fore margin. Frontal area with somewhat scarcer puncturation, smooth in front. Frons and its sides with rather even dense puncturation and velvety pilosity. Vertex and temples with raised black pilosity. Antennae black-brown below, joint 3 somewhat longer than the three following joints together. Mesonotum little shining, exteriorly with dense black pilosity, somewhat impressed in the middle, with irregular, in the middle

denser and finer, beside scarcer and coarser, exteriorly again denser and finer puncturation, the intervals of the punctures very finely rugosely granulated. Scutellum rather evenly densely and strongly punctured and, besides, with dense raised black pilosity. Postscutellum at the base with grey felt-cover, at the apex with raised black pilosity. Median area of the propodeum deepened in the middle and with a slight short median keel, apical half and middle of basal half smooth and shining, very finely and densely punctured, apical half at the margin more strongly shining and smooth, basal half at the sides with dense and coarse puncturation and, besides, with fine raised black hairs, the lateral areas of the propodeum as well as the side of the basal half of the central area, punctured and pilose. Abdomen only at the base of tergite I with fine raised, else with dense decumbent, black pilosity, the tergites I-IV at the base irregularly and rather strongly, at the apex evenly and more finely punctured, tergite V at base with rather dense and file-like puncturation, and with sparing adpressed pilosity, at the apex with dense velvet-black apical fringe. Tergite VI (pygidium) parallel-sided, rounded at tip, finely margined at the sides, surface almost without sculpture, the dense lateral pilosity covered with single white hairs. Sternites, particularly the anterior, of here and there at base and apex red brown colour, the puncturation uneven, denser and finer at base, scarcer and stronger at apex, the posterior margins with black fringe hairs. Legs clothed with black hairs, scopa of tibiae with scarce pale hairs between. Calcar of hind tibiae black, slightly reddish transparent. Fore wings black-brown with bluish sheen, hind wings little darkened. Tegulae black".

HABITAT : 1 female, Egypt (no locality mentioned), leg. A. ANDRES; 1 female, Dabaa (May), coll. Ministry of Agriculture.

This species I have tentatively placed in this group, the male being still unknown.

Anthophora armata Fr. var. tetra Fr.

1905. cf. *Anthophora armata* Friese, *Zeitschr. Hym. Dipt.*, V, p. 234.
1922. *Anthophora armata* v. *tetra* Friese, *Zool. Jahrb.*, Syst., 46, p. 10.

FEMALE : 19.5-22 mm. Black. Pilosity of the head, the whole legs and under side of body, and the tergites II-VI black of which tergites II and III are covered with very short, semi-erect dark hairs, IV and V with more distinctly raised such hairs, especially at the sides; thorax and abdominal tergite I everywhere, the former also at the sides, covered with short raised yellow to ferruginous pilosity. Tegulae ferruginous. Wings *strongly* shaded with dark brown and, besides, with distinct pubescence in the cells. The black pilosity of the fore and middle femora long beneath, of the hind femora short; hind tibiae and metatarsus III with long and coarse black hairs. Calcaria dark.

Genae not developed. Clypeus finely and densely punctured, without median carina. Antennal 3 at the apex gradually, not abruptly, thickened, about 3.5 times as long as broad, scarcely as long as the four following joints combined. Tergites shining, the ground chagreened and finely, densely punctured, more finely yet towards the posterior margins of the tergites. Nervulus interstitial.

HABITAT : 1 female, Gebel Elba, Wadi Aideb, February, 1933 (leg. H. PRIESNER, coll. Min. Agric.), identified by ALFKEN.

The male remained unknown to me. The male of the typical form is, according to FRIESE, characterized by the metatarsus III which bears at the base beneath a large pointed tooth. The clypeus is usually spotted with black, otherwise like the labrum yellow. Thorax with yellow or ferruginous hairs, coloration about as in *A. semirufa*, the under side of the body with black pilosity. Tergite I is only at the base covered with yellow hairs. Length 18 mm.

The typical form is obviously only ethiopic.

Group VII (quadrifasciata)

Anthophora carnea Gribodo

1894. *Anthophora carnea* Gribodo, *Bull. soc. ent. Ital.*, XXVI, p. 277 (female).
1897. *Podalirius carneus* Friese, Bienen Europas, III, p. 290.
1916. *Anthophora erubescens* Storey, Min. Agric., Techn. Bull. 5, p. 18.
1926. *Anthophora erubescens* Alfken (nec F. Mor.), *Senckenbergiana*, VIII, p. 100.

MALE : 14-15 mm. Body and legs ferruginous, thorax above and below blackened. Antennae dark, joint 1 yellow beneath. Face yellow, tips of mandibles brownish. Tergites (III-) IV-V sometimes blackened at base, and also the sternites IV-VI darkened at base. Pilosity of face not very long, whitish to pale yellow. Thorax with very short yellowish-white to ferruginous pilosity, without black hairs. Propodeum at the sides with long white pile. Tergites clothed with short adpressed hairs, tergite I only at base with some short raised hairs, rest with decumbent hairs. Tergites I-V with white marginal fasciae which are somewhat broader in the middle than at the sides; tergite VI at the sides with white hairs. Tibiae and metatarsi exteriorly clothed with whitish, interiorly with reddish, hairs. Calcaria yellow.

Clypeus little protruding, densely and finely punctured. Labrum transverse, slightly emarginated in front. Antennal 3 about twice as long as broad. Wings hyaline, veins ferruginous, pubescence noticeable only in cell r1. Nervulus slightly prefurcal. Tergite VII produced in a transparent, yellow, parallel-sided plate that is quite indistinctly excavated (almost straight) at the apical margin; median line carinated. Joint 5 of middle tarsi slender, without brush-hairs. Metatarsi slender.

FEMALE : Length 15-18 mm. Somewhat darker ferruginous. Face ferruginous, clypeus slightly brownish towards base, vertex and thorax dark on the ground;

abdomen dark yellowish-brown or ferruginous, legs ferruginous, with pilosity of the same colour. Antennal 1 ferruginous, paler below. Tegulae testaceous or ferruginous. Wings distinctly shaded. Anterior body with short reddish pilosity, the hairs being longer only on the vertex. Tergite I with dense, almost decumbent ferruginous hairs, tergites II-IV without longer, not even adpressed hairs, the lateral angles of tergites II and III with a small spot of short, adpressed, silky white, hairs. Hind margins of tergites II and III showing a very fine quite indistinct line of white hairs. Apex of tergite V clothed with somewhat longer, reddish hairs, like the sides of tergite VI. Tibiae and tarsi exteriorly with long ferruginous hairs.

Clypeus densely punctured, with fine smooth median keel. Genae not developed. Antennal 3 gradually thickened towards apex, scarcely three times as long as broad and about as long as the three following joints combined. Metatarsus III slender. Calcaria long, yellow. Venter with reddish marginal fringe of segments.

HABITAT : Uncommon; from the following localities : Mansuriah, Kerdasa, Abu Rowash, Pyramids of Giza, Cairo, Meadi, Wadi Digla, Helouan, Wadi Rasheed, Wadi Hussein (April-June).

ALFKEN has already hinted to the possibility that the specimen identified by him with *A. erubescens* F. Mor. actually belonged to *carnea* Grib. I have not seen the Transcaspian *A. erubescens*, but very much doubt that our Egyptian species (carnea) could be identical with it.

Anthophora crocea (Klug)

1845. *Megilla crocea* Klug, Symb. phys., Dec. 5, Ins., pl. 50, fig. 1 (male and female).
1897. *Podalirius croceus* Friese, Bienen Europas, III, p. 105 (erroneously as synonym of *A. concinna*).
1926. *Anthophora crocea* Alfken, *Senckenbergiana*, VIII, p. 100.

MALE : Length 9-11 mm. Black, femora and some sternites mostly reddish or brown. Antennae reddish below or brownish, joint 1 yellow below. Face yellow, only fronto-clypeal suture with black line. Margins of tergites broadly yellowish transparent. Labrum with short, face and vertex with longer, reddish pilosity. Hairs of the thorax reddish too, but, like the vertex, mixed with some black ones. Tegulae ferruginous, almost dull. Wings shaded with pale brown, *all cells distinctly pubescent*; nervulus distinctly prefurcal. Abdomen with marginal bands of decumbent ferruginous hairs, but the tergites in front of the fasciae, though less densely, covered with decumbent ferruginous or yellow hairs. Anal segment with black hairs and two small reddish teeth that are almost covered by the black hairs. Calcaria black. Tibiae with reddish or ferruginous pile, metatarsus III on both sides black-haired, only at base with a few pale hairs.

Antennal joint 3 less than 1.5 times as long as broad, about as long as joint 5. *Scutellum shining at base and sparingly punctured.*

FEMALE : Length 10.5-13 mm. Like the male, but posterior metatarsus exteriorly at base with a ferruginous hair-spot. Antennal 1 testaceous. Tergite I often red on the ground. Clypeus yellow, with 2 large brownish-black spots leaving a parallelsided yellow line between them. Frontal area forming a flat yellow triangle. Antennal 3 almost three times as long as broad, somwhat shorter than joints 4-6 combined.

HABITAT : A southern species. Kom Ombo, Assouan, Mersa Halaib, Gebel Elba; Arabia (El-Minawarah).

Though varying in ground-colour from ferruginous to dark brown, the species is unmistakable.

Anthophora klugi nom. nov.

1926. *Anthophora farinosa* Alfken, (nec Klug), *Senckenbergiana*, VIII, p. 100.

MALE : Length 11-13 mm. Black. Antennae, except joint 1 which is whitish beneath, always dark. Face ivory-white, clypeus only at base towards the sides of the frons with dark line, without spots. Pilosity as described for the female, but tergite I of the abdomen only with pale hairs, no black hairs present, only the dark ground is somewhat visible across middle. Tergites with four complete and one incomplete, medially interrupted, *white* fasciae. Metatarsi I and II exteriorly clothed with white hairs, metatarsus III with black hairs only, or with very few white hairs at base.

Clypeus moderately strongly protruding, the sides of the frons not quite reaching the anterior lateral angles of the clypeus. Antennal 3 not quite twice as long as broad, joint 4 somewhat transverse. The excavation between the two small teeth of tergite VII is straight for some distance.

FEMALE : Length 13-15 mm. Ground colour black, antennae wholly black. Face very pale yellow, sides and large spot on the clypeus black, the spots being interiorly comparatively widely separated (cf. *quadrifasciata*), the pale interval being distally not quite twice as broad as the width of the flagellum; the spots are anteriorly somewhat emarginated but less so than in *quadrifasciata*, and the pale median line is nearly always slightly conical, somewhat narrowed towards base. Labrum somewhat broader than long. Head clothed with white, *thorax with greyish-yellow hairs*, vertex and thorax having black hairs intermixed; under side with white hairs. Tergite I with raised white hairs, but across the middle also with black hairs (in the male only with white hairs). Fasciae of the tergites broad, white, on I-IV complete, on V only laterally developed; the sternites are from II-V laterally fringed with white hairs. Tibiae exteriorly densely set with decumbent white hairs, metatarsus II at the exterior margin with white, metatarsus III on both faces with black, hairs. Tegulae testaceous, dull.

Antennal joint 3 well three times as long as broad. Genae wanting. Wings slightly shaded and distinctly pubescent in the cells. Nervulus prefurcal. Posterior metatarsus rather broad and appearing conical on account of the marginal black hairs becoming shorter towards apex.

HABITAT : The species is rather common and widely distributed (April-December).

A. klugi comes closest to *quadrifasciata* Vill. and differs in the female by its larger size, on an average, the broader pale median stripe of the clypeus, the paler colour of the pile, especially also the pure-white fasciae which are a little broader than in *quadrifasciata*; the male is more difficult to distinguish, except for the colour of the thorax which shows a grey or whitish yellow pilosity, instead of ferruginous as in *quadrifasciata*; the excavation between the teeth of tergite VII is straight for some distance, instead of rounded, the antennae are straight as to their segments whilst they are often indistinctly wavy, in *quadrifasciata*; the fasciae of the tergites are slightly broader.

Our species was considered to be identical with *A. farinosa* Klug (from Arabia), by ALFKEN. Although the two species are rather similar to each other in many respects, they are not identical, as I could see from the examination of the types of *A. farinosa*. In the latter species thorax and abdominal tergite I of the female show uniformly pale hairs, while in all specimens of *klugi* black hairs can be seen among the pale ones. The pale spots of the clypeus are yet shorter in *farinosa*, than in *klugi*; the antennae have the flagellum brown below, in *klugi* always black; the pygidial area is transversely chagreened having in the middle a very narrow smooth longitudinal line, in *klugi* the face of the VIth tergite is quite evenly chagreened. The male type of *farinosa* is in the pilosity of the abdomen much more similar to *A. savignyi* than to *klugi*; the teeth of tergite VII are much closer together, and separated by a round excavation; the fasciae are relatively broader and have a short white median line, and the fascia on tergite V is complete, as in *savignyi*; head and thorax are clothed with yellow-grey hairs, without black hairs between; the flagellum is ferruginous beneath; the posterior metatarsus is much more slender than in *klugi*. ALFKEN, who also examined the types, attached a label to the pin of the male specimen : Dürfte nicht das Männchen von *farinosa* sein". However, the specimen —though only 11 mm. long — may well belong to the female type, as it shows the same coloration of the pilosity, and agrees with the female in the pale flagellum. In any case, neither male nor female of *farinosa* are identical with the Egyptian species.

I had to give a new name because FRIESE's *A. wegeneri*, which I for some time held to be identical with *klugi*, is a synonym of *A. alternans* Kl., since the description given by FRIESE, as well as the type (seen by ALFKEN) prove this synonymy. FRIESE had obviously mixed up the two species, since of the four specimens (in the Vienna Museum) labelled "*wegeneri* type" three are *klugi* and one is *alternans* (q.v.).

Anthophora quadrifasciata Vill.

1790. *Apis quadrifasciata* Villers, C. Linnaei Entom., III, p. 319.
1812. Unnamed, Savigny, Descr. d'Egypte, pl. I, fig. 14 (female).
1916. *Anthophora quadrifasciata* Storey, Min. Agric., Techn. Bull. 5, p. 18 (pro parte).
1926. *Anthophora quadrifasciata* Alfken, *Senckenbergiana*, VIII, p. 100.

MALE : Length 13-14.5 mm. Extremely similar to the male of *klugi*, but in the Egyptian race differing in having slightly narrower bands of the abdomen, and very slightly slenderer metatarsus III, rounded interval between the teeth of tergite VII, the possession of a few black hairs on tergite I, and sometimes not absolutely straight flagellar joints. The pile of the thorax is in fresh specimens ferruginnous, and the basal fasciae are usually yellowish, not pure-white.

FEMALE : Length 12-14 mm. From *klugi* differing by the following characters: The black spots of the clypeus are in the middle somewhat less broadly separated so that the yellow median stripe is only a little broader than the flagellum, and is parallel-sided, not or scarcely narrowed towards base; the pale fore margin of the clypeus is narrower and the distal excavation of the black spots on either side is stronger, and their fore margin therefore more oblique on both sides. The pilosity of the thorax is ferruginous (in the Egyptian form of the species), in *klugi* yellowish-grey; the pale fasciae of the abdomen, at least of the tergites I-II (-III) show a yellowish tinge and are a little narrower than in *klugi*.

HABITAT : The species is widely distributed but obviously somewhat less common in this country than *klugi*; it was found in Middle Egypt (e.g. Meadi, Turrah) as well as at the northern coast (from Damiette to Mersa Matrouh). March-December.

A. quadrifasciata is at first sight somewhat similar to *magnilabris* Fedt.; but in this species the clypeus protrudes more strongly, the labrum is square, the flagellum ferruginous beneath, and the sides of the frons attain nearly the base of the mandibles, their tips reaching the level of the fore angles of the clypeus.

Anthophora magnilabris Fedtsch.

1875. *Anthophora magnilabris* Fedtschenko, Turkestan. Apid., I, p. 22 (male and female).
1897. *Podalirius magnilabris* Friese, Bienen Europas, III, p. 90.

MALE : Length 11 mm. Ground colour black, face pale yellow; frontal area triangularly pale yellow. Flagellum ferruginous below, joint 1 of antennae yellow below. Face with little dense white pilosity. Thorax clothed with pale yellowish-grey hairs, without black hairs. Tergites I-IV with fasciae of white decumbent hairs that are about as broad as in *A. quadrifasciata*, tergite V with broadly interrupted white fascia or entirely black. Tibiae and metatarsus II exteriorly clothed with adpressed white hairs, metatarsus III on both faces with black hairs, only exteriorly

at base with very few white hairs. Pilosity of the metatarsus not long, and therefore the metatarsus appearing slender. Tarsi and calcaria black. Posterior margins of the sternites and posterior femora not fringed with white hairs.

Clypeus very strongly protruding, labrum square, appearing slightly elongate. Sides of frons broad, their tips almost reaching the mandibles. Genae wanting. Antennal 3 about 1.5 times as long as broad, 4 slightly transverse. Tegulae testaceous, pubescent. Wing cells distinctly pubescent. Tergite VII with two small teeth that appear black owing to their pilosity, and are separated by an arched interval.

The female is unknown to me, and, since the species was confused with others by FRIESE and ALFKEN, I can only refer to FEDTSCHENKO's description : with yellow pilosity above, segments I-IV with white marginal fasciae. Flagellum ferruginous below. Face yellow or pale pink, clypeus densely punctured, with angular black basal markings. Labrum almost rugose. Antennal joint 3 shorter than the three following joints combined. Tibiae exteriorly with white hairs. The labrum is also in the female very long. Sides of frons yellow.

I only know 2 males from Egypt (Borg, March, coll. PRIESNER; Mamoura, coll. Min. Agric.); these fully agree with a male of *magnilabris* Fedt. (from Transcaspia) labeled by FRIESE (in coll. Mus. Vienna). Another specimen in the same collection (from Syria) is *A. savignyi* Lep., a species that is easily distinguished from *magnilabris* in having a full fascia on tergite V, slightly transverse labrum, intermixed black hairs at the clypeo-frontal suture, on the vertex and thorax, narrower abdominal fasciae and a small white hairspot exteriorly at the base of the metatarsus III. Another male of my collection (from Wadi Gerawi, November) was identified by ALFKEN with *magnilabris* but is nothing else than a rubbed specimen of *savignyi*, too.

Anthophora litorana spec. nov.

MALE : 11-12.5 mm. Black, antennal joint 1 beneath and face, i.e. sides of frons, mandibles, labrum, clypeus and frontal area (in the shape of a flat triangle or brace), ivory-white; an elongate fine marking at the clypeo-frontal suture black. Flagellum black. Wings hyaline, veins brown. Face with little densely set white hairs. Thorax with yellow-grey hairs, not mixed with black hairs. Abdominal tergite I with raised whitish-yellow pilosity, the tergites I-V with *narrow* fasciae of decumbent white hairs at the hind margins; on tergite V the fascia is interrupted in the middle and replaced there by dark *brownish* hairs; this interruption is in all specimens broader than in *A. klugi*. Head and thorax beneath with grey, sternites of the abdomen with short, almost adpressed brown hairs, without white fringe. The tergites are in front of the fasciae clothed with decumbent brown-black hairs, and with a few semierect dark hairs. Middle tibiae and tarsi exteriorly, like the hind tibiae, with decumbent white hairs, the hind tarsi, however, on both faces with black hairs; metatarsus III at the extreme base with only a few white hairs.

Clypeus distinctly protruding, with scattered, shallow puncturation. Labrum little broader than long. Sides of frons reaching with their tips the base of the mandibles. Antennal joint 3 short, not quite 1.5 times as long as broad. Genae wanting. Tegulae testaceous. Wings distinctly pubescent in the cells, also m 2 and m 3 with some microsetae. Nervulus somewhat prefurcal. Tergite VII with very short and small teeth that are separated by an almost straight interval; pilosity about the teeth short. Metatarsi of middle and hind legs *slender*, the whole hind tarsi slenderer than in *A. klugi*, the difference particularly noticeable in joint 2. Ultimate joint of middle tarsi slender, without black hairs. — Female unknown, but most likely differing from *A. klugi* by the narrower fasciae of the abdomen.

HABITAT : The types are from Mersa Matrouh, 20.viii.1955 (coll. Ain Shams Univ.); in the collection of the Ministry of Agriculture there is 1 male from Sinai (Wadi Feiran — St. Katherine, 28.v.1935, leg. M. KASSIM).

Belonging to the *quadrifasciata*-group this species differs from the similarly coloured *A. klugi* by the slightly yellowish tinge of the whitish face parts, the narrower fasciae of the tergites, the shorter teeth of tergite VII, the broader interruption of the white band of tergite V and by the slenderer tarsi. Although the clypeus is strongly protruding, it is yet less convex than in *A. magnilabris* which has, besides, narrower labrum, narrower face, broader metatarsi and has the flagellum ferruginous below.

I should have held this to be a littoral subspecies of *klugi*, if the latter species would not occur at the costal area, too.

Anthophora andresi Friese

1914. *Anthophora andresi* Friese, *Stettiner Ent. Zeitg.*, LXXV, p. 220 (male and female).
1926. *Anthophora glauca* Aifken, *Senckenbergiana*, VIII, p. 118 (male and female).

MALE : Length 9-10 mm. Ground colour black, antennae wholly black, also joint 1. Face white, but the clypeus only in the middle broadly triangularly white, like the labrum and the mandibles. Sides of frons black. Face with very short white pilosity. Thorax above clothed with white hairs, mixed with many black ones. Tergite I without black hairs, tergites I-IV with moderately broad marginal fasciae of adpressed hairs, tergites V-VII with dull dark brown, in other specimens with black tomentum. Tibiae exteriorly with white hairs, metatarsus II only at base or upper margin at base with white hairs; the hind tarsi only with black hairs. Sternites without white hairs.

Clypeus with very fine and dense puncturation. Antennal 3 scarcely 1.5 times as long as broad, 4 little transverse. The antennae are comparatively long, the intermediate flagellar joints not quite twice as long as broad. Tegulae pale brown or testaceous. Nervures of wing, except costa, dark, the cells without pubescence. Nervulus prefurcal. Metatarsi slender. Tergite VII with distinct but small reddish teeth which are separated by a semicircular interval and not surrounded by longer hairs.

FEMALE : Length 8.5-12.5 mm. Black, mandibles, labrum, fore margin of clypeus and a *wedge-shaped* median line of it, white, frontal area often wholly dark, never *broadly* white. Colour of pilosity as in the male; vertex much mixed with black hairs. Abdominal fasciae broader, full on tergites I-IV, *tergite V only at the sides with white hairs*, in the middle with velvet-black hairs. Sides of the sternites at the hind margins with white hairs.

Clypeus without median keel, with moderately dense, shallow puncturation. Antennal joint 3 scarcely three times as long as broad, gradually thickened towards tip, shorter than the three following joints together. Metatarsus III appearing conical, on account of the decreasing length of the marginal hairs. Wings as in the male without cell-pubescence.

HABITAT : Widely distributed and locally common, recorded from the following localities : Mersa Matrouh, Amriah; Kerdasa, Giza Pyramids, Gebel Asfar, Wadi Digla, Meadi, Helouan, Wadi Hof; Fayed. (April-November).

The type (male) of FRIESE's *A. andresi* bears two labels (Mariout, 20.ix.07 and Ikingi, 11.ii.12) the latter one obviously a specimen collected by A. ANDRES, as mentioned in the description by FRIESE (l.c.), the former label perhaps formerly belonging to another specimen having been lost. In any case is this specimen identical with others identified by Alfken as *A. glauca*. A female type (from Cairo) must have been examined by ALFKEN, since it bears the additional label in ALFKENS' handwriting: "*A. leucomelaena* D.T. = (*melaleuca* Walk.); this specimen, too, is identical with *glauca*. The specimens of *glauca* (det. ALFKEN in ALFIERI's collection are again the same. Whether WALKER's *melaleuca* is the same as *andresi* (*glauca*) or perhaps the species described below, we shall never be able to decide, since WALKER's types are destroyed. ALFKEN's *A. leucomelaena* (*Ent. Mitt.*, XVI, p. 151; 1927) from Port Sudan is another species, not identical with *A. andresi*.

Anthophora omissa spec. nov.

FEMALE : 9.5-10.5 mm. Black. Face pale yellow (i.e. labrum except 2 dark basal points, mandibles with the exception of the brown tips, fore margin and a mostly conical median stripe of the clypeus, and the frontal area (a flat triangle); the black sides and base of the clypeus occupy well two-thirds of the length of it. Face with not very dense whitish pilosity, vertex, besides, with a few black hairs; thorax with grey pilosity, i.e. many black among the white hairs. Abdominal tergite I with white, without black hairs, tergites I-IV with full, rather broad, sharply defined marginal fasciae of adpressed white hairs, tergites II-IV in front of the fasciae with black decumbent hairs; *tergite V and the whole end of the abdomen only with black hairs, tergite V at the sides without any white hairs*; tergite IV also with a few semi-erect black hairs. Middle and hind tibiae exteriorly with white hairs, metatarsus II only at the basal margin above with single white hairs, metatarsus III on either face

with black hairs. Under side of thorax with white, sternites of the abdomen with black hairs only. Calcaria dark.

Labrum only slightly transverse, rugosely punctured; clypeus coarsely punctured. Antennal joint 3 not quite three times but somewhat more than 2.5 times as long as broad, gradually thickened towards tip. Tegulae brown with paler margins, pubescent. Wings hyaline, veins dark, cells m 1, r 1 and sc distinctly pubescent. Nervulus decidedly prefurcal.

MALE unknown.

HABITAT : I collected 4 specimens of this species in April at Mersa Matrouh.

Closely related to *A. andresi*, this species differs by the black pilosity of the whole Vth tergite, the lack of white hairs at the margins of the sternites, the pubescent anterior wing cells, and distinctly pale yellow, not ivory-white, colour of the face, and is certainly specifically different.

Anthophora savignyi Lep.

1841. *Anthophora savignyi* Lepeletier, Hist. nat. Ins. Hym., II, p. 47 (female).
1897. *Podalirius savignyi* Friese, Bienen Europas, III, p. 308.
1926. *Anthophora savignyi* Alfken, *Senckenbergiana*, VIII, pp. 100, 117 (male and female).

MALE : 9-12 mm. Black, antennal joint 1 beneath, frontal area (angular above), sides of frons, clypeus, labrum and mandibles (tips darker), yellow; suture between clypeus and labrum, 2 basal dots of the latter and a comma-shaped spot between clypeus and basal sides of frons, black. Flagellum not or scarcely paler beneath. Frons with short raised pale yellow and black mixed pilosity. Vertex and thorax clothed with ferruginous to yellow-grey hairs, with many black hairs between, and tergite I of abdomen with the same kind of clothing. Tergites I-V with white, comparatively narrow fasciae, disk in front of them black; there is also a *short* raised black pilosity present in front of the bands, that becomes somewhat longer on tergite V. Middle tibiae and tarsi exteriorly with yellow-grey to whitish hairs, of the tarsi at least the whole metatarsus and joint 2 with white hairs. Hind tibiae with the same pilosity but metatarsus III only at the extreme base with a white hair-spot that often occupies one-third of its length but may be much shorter. Sternites somewhat reddish transparent, the apical margins with whitish fringe. Calcaria dark.

Clypeus dull, with scattered shallow puncturation, distinctly protruding. Antennal 3 not quite twice as long as broad. Tegulae ferruginous, pubescent. Puncturation of the tergites moderately dense. Tergite VII with 2 dark well developed small teeth which are separated by a straight interval. Wings almost hyliane, fore wings pubescent in almost all cells (m1, m2, m3, r1, r2, r3, sc). There exist smaller males in which antennal 3 is only little longer than broad, tergite I has only very few black hairs, the metatarsus III at base only few white hairs, and the thoracic

pilosity is a little paler. In agreement with ALFKEN I consider these to be only small specimens of *savignyi*, and not another form.

FEMALE : 10.5-12 mm. Black. Frontal area (triangular), clypeus, labrum, mandibles (with dark apices) and sides of frons yellow; clypeus with two large elongate spots which are angular exteriorly (laterally). Antennae black, but flagellum sometimes reddish beneath. The basal sternites mostly reddish. Pilosity and fasciae of the abdomen as in the male, tergite V all across with white hairs, and with black median velvet-spot posteriorly. The fasciae are usually slightly produced in the middle in a fine short line of white hairs. Pubescence of wing as in the male.

Antennal 3 long, thickened at the apex, well three times as long as broad, longer than the three but shorter than the four following joints together. Nervulus prefurcal.

HABITAT : Common everywhere and distributed all over Egypt, also collected in Sinai and Mersa Halaib (Gebel Elba). The whole year round.

Anthophora punctifrons Walker

1871. *Anthophora punctifrons* Walker, List Hym. Egypt, p. 57 (female).
1897. *Podalirius punctifrons* Friese, Bienen Europas, III, p. 305.
1899. *Podalirius albigenus* var. *flaviceps* Friese, *Ent. Nachrichten*, XV, p. 322 (male and female).
1926. *Anthophora punctifrons* Alfken, *Senckenbergiana*, VIII, pp. 100, 117 (male and female).

MALE : Length 8.5-9.5 mm. Black, terminal tarsal joint or its tip sometimes reddish, basal abdominal sternites often reddish-brown. Antennal joint 1 beneath and the whole face yellow; frontal area distinctly triangular in shape; clypeus only with black dot or comma at its suture towards sides of frons; flagellum ferruginous, somewhat brownish above, antennal 3 mostly wholly ferruginous. Face with short whitish, thorax and tergite I of the abdomen with longer whitish-yellow hairs, well mixed with black hairs; tergites I-V with moderately broad white fasciae of decumbent hairs, and black decumbent pilosity in front of the fasciae; only tergite IV with a few short semi-erect black hairs. Middle tibiae and metatarsus II (but not joints 2-5) and the hind tibiae with decumbent white pilosity, metatarsus III on both faces with black hairs, at most at the extreme base exteriorly with single white hairs but without hair-spot. Calcaria dark. Head and thorax beneath with white hairs, the sternites with dark hairs, only laterally at the hind margin with a few white fringe hairs.

Labrum and clypeus dull, shallowly punctured, labrum square, clypeus *little* protruding. Antennal joint 3 short, little longer than broad. Tergites with fine and dense puncturation. Tergite VII with 2 well developed small teeth that are reddish at tips and separated by a broadly arched or straight interval. Tegulae ferruginous, dull. Wings scarcely shaded, veins dark, only costa often yellowish, the anterior cells distinctly pubescent and also in cells m2 and r2 some microsetae. Nervulus distinctly prefurcal.

FEMALE : 8-10.5 mm. Black, flagellum about from apex of antennal 3 onwards ferruginous, often darkened above. Antennal 1 beneath and face yellow, clypeus with two quadrangular black spots which are exteriorly limited by the yellow sides of the frons, and anteriorly straight or slightly emarginated, the exterior angle is right or pointed. Frontal area large, triangular, yellow, broader than the yellow median stripe of the clypeus. Vertex, thorax and abdominal tergite I profusely mixed with black hairs, grey-yellow to yellow. Fasciae of the tergites I-V white or anteriors with yellow tinge; tergite V in the middle of the hind margin with black pilosity, also the basal white mixed with black hairs. Sternites as in the male. Tibiae exteriorly clothed with white, like metatarsus II (at base and upper margin), metatarsus III on both faces with black pilosity, at base mostly with several white hairs.

Face flattened, labrum little transverse, dull, densely punctured, clypeus less densely so, shining, especially in the middle. Antennal 3 2.3-2.5 times as long as broad.

HABITAT : Middle and Upper Egypt and also in the Canal Zone, common (April-October). Sudan.

The species was formerly considered to be identical with *A. annulifera* Walker, but ALFKEN changed his opinion and gave it later the name: *A. punctifrons* Walker. In *A. annulifera* the face is, according to WALKER, entirely pale, without black spots (female), our species can therefore not be identical with it. WALKER'S *A. punctifrons* has black dots, the 1st antennal is yellow below (female) and the pilosity of the tarsi seems to agree, too. With some hesitation I have to adopt ALFKEN'S interpretation. *A. albigena flaviceps* (l.c.) is surely identical with our species, as the examination of the type specimens confirmed. ALFKEN specimens of *punctifrons* from El-Obeid (Sudan) are also the same.

Anthophora albigena Lep. ssp. afra nov.

1841. *Anthophora albigena* Lepeletier, Hist nat. Ins. Hym., II, p. 28.
1897. *Podalirius albigenus* Friese, Bienen Europas, III, p. 77 (further references).
1916. *Anthophora albigena* Storey, Min. Agric., Techn. Bull. 5, p. 15.

MALE : Length 9-10 mm. Ground colour black, face and antennal joint 1 beneath dull white; clypeus at the lateral suture with black arched line; frontal area a flat triangle, and sides of frons white. Clypeus and labrum little hairy. Thorax with yellow-grey hairs, mixed with black hairs, and also the vertex and the lateral suture of the clypeus with a few black hairs. Abdominal tergite I in the middle across with black raised hairs. Tergites with adpressed black pilosity on the disks and normally wide white fasciae on tergites I-V; the fasciae are medially slightly produced by a fine line. Tergite VI only at the sides with a few white hairs. Middle tarsi exteriorly with white hairs, also their joints 2 and 3; metatarsus III only in the basal third with white decumbent hairs.

Clypeus finely and sparingly punctured, slightly protruding. Genae not developed. Antennae rather long, flagellum dark or slightly brownish below, antennals 3 and 4 mostly palest; joint 3 short, only a little longer than broad, the intermediate joints not quite twice as long as broad. Tegulae testaceous. Wings hyaline, fore wing distinctly pubescent in the anterior cells. Nervulus prefurcal. Tergite VII with two distinct small teeth, the interval between them little rounded, straight at least for a short distance.

FEMALE : Length 9-11 mm. Antennae dark, clypeus with very large black spots so that only the fore margin (laterally broader) and a narrow median line, as well as a narrow frontal area, remain white; sides of frons dark, rarely narrowly white. Pilosity as in the male or on the thorax grey mixed with black hairs; tergite I of the abdomen with raised white hairs, without black hairs. The white fasciae of the tergites somewhat broader than in the male, but they are medially less distinctly produced than in *A. pipiens*. Middle tibiae and tarsi and hind tibiae exteriorly clothed with white hairs; metatarsus III exteriorly with a large white basal hair-spot. Sides of the margins of the sternites with white fringe (as in the male).

Clypeus densely punctured. Antennal joint 3 scarcely three times as long as broad, gradually widened towards apex and about as long as the three following joints together. Puncturation of the tergites very dense.

HABITAT : The species is widely distributed in the country; I saw it not only from the desert valleys around Cairo-Helouan, but also from the northern coast (Mersa Matrouh, Ikingi), Gebel Ataqa, Red Sea coast (Wadi Abrag) and the Sinai. (April-January).

The specimens of *Anthophora albigena* Lep. from South Europe (coll. Mus. Vienna, coll. PRIESNER), identified as such by FRIESE and ALFKEN, respectively, have in the male the whole metatarsus III covered with decumbent white pilosity, whilst in all Egyptian specimens the metatarsus bears black hairs in the distal two-thirds. The latter seem to represent a special variety or race of the species. Other varieties of *A. albigena*, so far as the are known, are not identical with ours.

A. albigena can hardly be confused with *A. punctifrons*, since the latter species has a yellow face and ferruginous flagellum, and its 3rd metatarsus has only a few white hairs at the base. *A. pipiens* Mocs. is similar, but in the latter the frontal area is black, the clypeus in front only very narrowly pale, and the white fasciae are distinctly linearly produced in the middle.

Anthophora pipiens Mocsary

1876. *Anthophora salviae* Morawitz, *Hor. soc. ent. Ross.*, XII, p. 29 (male); preoccupied by *salviae* Panz., 1805.
1879. *Anthophora pipiens* Mocsary, *Magy. Tud. Akad. Termész. Kozlem*, XVI, p. 9 (male and female).
1897. *Podalirius salviae* Friese, Bienen Europas, III, p. 83.
1916. *Anthophora salviae* Storey, Min. Agric., Techn. Bull. 5, p. 18.

MALE : Length 8.5-9.5 mm. Black, antennae black. Clypeus in front, labrum and mandibles (tips brown), white; clypeus with two rectangular basal markings

fused with the sides of the frons and occupying about half of the clypeus' length; frontal area a flat white triangle connected with the white fore margin of the clypeus by a pale median line. Pilosity of frons and vertex short whitish, black hairs by the ocelli. Hairs on thorax grey-yellow, well mixed with black ones. Tergite I predominantly covered with pale hairs, tergites II-V with decumbent black hairs and few raised black hairs of medium length; posteromarginal fasciae on tergites I-V white, normal, sometimes with fine longitudinal short line in front of middle. Head and thorax beneath with white-grey, sternites with very short white hairs at the sides, without longer fringe hairs. Tibiae and the *whole tarsi* exteriorly clothed with white, interiorly with black, hairs. Calcaria dark. Tegulae brown with dark center.

Labrum somewhat transverse. Clypeus not much protruding, nearly dull. Antennal 3 short, not even 1.5 times as long as broad. Wings hyaline, with distinct pilosity in the cells m1, r1 and sc, near the fore margin of the wing. Veins black. Nervulus prefurcal. Tergite VII with two small teeth which are separated by a rather straight interval.

FEMALE : Length 9-10 mm. Black; labrum, mandibles (with red apices) and very narrowly the fore margin of the clypeus and a median line not reaching base, white. Pilosity of head and thorax as in the male, though with somewhat greater number of black hairs. The pilosity of the tergites is on II-V almost solely decumbent, without longer hairs. Hind tibiae exteriorly clothed with white to greyish-white hairs and the metatarsus III has a large white hair-spot at base that almost attains the apex. Calcaria dark. Tegulae brown or paler. Wings as in the male or the whole cell m1, also part of m2 pubescent; interior face of metatarsus III with dark brown hairs.

Labrum transverse. Clypeus dull. Antennal 3 scarcely three times as long as broad, about as long as the three following joints combined.

HABITAT : Uncommon; Kerdasa, Abu Rowash; Wadi Hussein; Wadi Galala; Sinai (Kosseima). (March-May).

Anthophora montivaga Fedt.

1875. *Anthophora montivaga* Fedtschenko, Turkest. Apid. I, p. 34, pl. 3, fig. 13 (male).
1894. *Anthophora montivaga* Morawitz, *Horae soc. ent. Ross.*, XXVIII, p. 22 (female).
1897. *Podalirius montivagus* Friese, Bienen Europas, III, p. 87.

MALE : "Maxillary palpi 5-segmented; black, head, thorax and 1st abdominal segment grey pilose; occiput and mesonotum with numerous black hairs intermixed; abdominal segments 1-5 with white-banded apical margin; calcaria black to piceous. Mandibles, labrum, fore margin and a longitudinal line of the clypeus as well as a small triangular band on the scutum (sc. frontal area) pale ivory-coloured; antennae wholly black. Length 11 mm." (FEDTSCHENKO).

FEMALE : "Genae wanting, labrum slightly transverse, 3rd antennal joint shorter than the three following joints combined; black, tegulae fusco-piceous,

mandibles, labrum, a narrow apical (on both sides abbreviated) fascia and a longitudinal line of the clypeus and a dot of the frontal area pale yellowish; head and thorax beneath grey pilose; thorax above with cinereous or blackish raised pilosity; wings slightly infumated, with dark veins, ordinary transverse vein prefurcal; abdominal tergites with black raised hairs, 1-4 at the apex fringed with grey-white, sternites with black, on either side with white, fringe; legs exteriorly with white, interiorly with black hairs, posterior metatarsus with dark penicillus at apex. Length 12-13 mm." (F. MORAWITZ).

To this original description (in Latin) FRIESE adds that the female is characterized by the limited pale markings of the face, i.e. a small triangular frontal area, a very narrow apical line of the clypeus which is abbreviated on either side, and, fused with it, a cuneiform marking, pale yellow. It is similar to *A. albigena* but somewhat larger. FRIESE mentions, besides the original specimens from Turkestan, such from Algeria and *Cairo*.

I have not seen Egyptian specimens but only the male, noted also by FRIESE, in the collection of the Vienna Museum. From this I noted the following characters: Antennae black. Pilosity white, on vertex and thorax mixed with black. Clypeus with median line and fore margin broadly whitish, sides of frons black, labrum with two black dots. Antennal 3 longer than 4, much shorter than 4-5. Tergites with distinctly raised black hairs, tergites I-V with white fasciae, that on V interrupted in the middle where the hairs are brown. Metatarsus III exteriorly wholly clothed with white hairs.

The species is very close to *A. pipiens* but larger (female 13-14 mm.) and has tergite V dark-haired; the fasciae of the preceding tergites are not produced in the middle. In the male, having a length of 11 mm., the fascia on tergite V is interrupted in the middle, while it is full in *pipiens*.

The male is characterized by the clypeus spots, the wholly black antennae, the sharply defined fasciae and the exteriorly wholly white-haired tarsi. The female is recognized by the dark clypeus design and the white hairs of the whole outer face of the metatarsus III, and might only be mistaken with *albigena afra* which has, however, a pale brace-shaped frontal area and, joined with it, a complete median stripe of the clypeus, and also a pale incision at the sides between the clypeus and the sides of the frons.

Anthophora mucorea (Klug)

1845. *Megilla mucorea* Klug, Symb. phys., Dec. 5, Ins., pl. 49, fig. 13 (female), **14** (male).
1897. *Podalirius mucoreus* Friese, Bienen Europas, III, p. 66.
1916. *Anthophora mucorea* Storey, Min. Agric., Techn. Bull. 5, p. 18 (partim).

MALE : Length 8.5-10 mm. Black, face ivory-yellow, dull; labrum, mandibles (with red tips), clypeus, frontal area (a flat triangle) pale. Antennal joint 1 dark, not white beneath, but more or less densely set with white hairs. Flagellum dark

or brown beneath, not ferruginous. Face with short white, thorax with short grey to yellow-grey pilosity, without black hairs. Tergites I-V with rather *broad* white fascia of decumbent hairs, tergite I with raised white hairs; on tergites II and III the black hairs in front of the fasciae are almost adpressed and there are only few semi-erect hairs present. Tibiae and the whole metatarsus II is exteriorly clothed with decumbent white hairs, metatarsus III with black hairs and a few white hairs at the extreme base, without hair-spot. Specimens from the Gebel Ataqa show also in front of the fasciae some scattered white hairs; if such occur in all fresh specimens or if it is a varietal character, I could not say.

Clypeus little protruding, with very fine, medially scattered puncturation. Antennal 3 short, little longer than broad. Tegulae testaceous. Wings hyaline, costa yellow, the other veins basally yellow, of the cells are only those of the fore margin near the costa pubescent. Nervulus distinctly prefurcal. Tergite VII with two *short*, reddish teeth that are separated by a reddish transparent membrane and the teeth are therefore much shorter and broader than in *albigena* or *byssina*. Sternite VI is posteriorly around the transverse impression smooth, strongly shining, scarcely punctured.

FEMALE : Length 10-11 mm. Black, sternites sometimes reddish, also the femora and tibiae sometimes reddish. Face partly white, with two angular black basal spots, sides of frons black, frontal area small, white. Antennal 1 dark, with white hairs beneath, flagellum from antennal joint 4 ferruginous below, or all joints so. Vertex, thorax and scutellum base with a few black hairs among the pale ones, but often the whole thorax shows only pale pilosity. The fasciae of the tergites are broad, almost reaching the base, particularly at the sides, and the fasciae are less well limited in front than in other species; tergite V bears a large median velvet-spot of black hairs, like in *byssina*. Tibiae and metatarsus II exteriorly with white hairs, metatarsus III on both faces black, with only a few white hairs at the base or none at all; the metatarsus is broad, conical on account of the black hairs becoming gradually shorter towards the tip of the metatarsus. Pubescence of wing cells about as in the male.

Clypeus convex, rather coarsely punctured, shining in the middle. Antennal 3 about three times as long as broad.

HABITAT: Widely distributed, especially in Upper Egypt, while it is uncommon in the region of Cairo and at the Canal Zone (Cairo, Helouan, Wadi Rasheed; Gebel Ataqa, Fayed; Assiout, Assouan, Oasis Kharga; Gebel Elba). January-November.

This species has repeatedly been confused with others, e.g. with *byssina*, *latizona* and even with *crocea*. The latter species is, even in old, pale specimens easily distinguished by the profusely pubescent wing cells and the shining scutellum with its scattered puncturation at the fore margin. *A. byssina* differs in the male in the pilosity of the tergites which is always extended up to the basal ridge, the sharper teeth of tergite VII, the dense white pile of the clypeus covering the ground and the densely punctured, only slightly shining, sternite VI of the abdomen.

In the female of *byssina* the frontal area is seldom somewhat whitish, the clypeus more densely and finely punctured, the white pilosity of the tergites attains the basal ridge (8) and the cell pubescence is yet less distinctly visible. The male of *A. latizona* bears white hairs all over the exterior face of the 3rd metatarsus, and the female has a great number of black hairs among the pale ones on the thorax, densely punctured clypeus, a large white basal spot of hairs at the 3rd metatarsus and somewhat shorter antennal joint 3.

In the Vienna Museum, there stand some specimens of *A. mucorea* determined by FRIESE as *alternans*, but correctly named *mucorea*, by KOHL.

Figure 15 (female) on plate I of SAVIGNY's "Description d'Egypte" may refer to *A. mucorea* but I am not sure about it; neither am I about the possible identity of WALKER's *Anthophora pulverea* (List Hym. Egypt, p. 57; 1871).

Anthophora latizona (Spin.)

1812. Unnamed, Savigny, Description d'Egypte, pl. I, fig. 19 (female).
1838. *Saropoda latizona* Spinola, *Ann. soc. ent. France*, III, p. 543 (female).
1897. *Podalirius latizonus* Friese, Bienen Europas, III, p. 107 (female).

MALE : Length 8.5-10.6 mm. Ground black, only tergite I of the abdomen may sometimes be reddish-brown as well as the basal sternites. Face white, sides of face dark, antennal 1 white beneath, flagellum somewhat ferruginous but mostly joints 1-3 black. Face with dense, almost decumbent, laterally short, raised white pilosity. Thorax covered with grey hairs, mixed with some black hairs, tergite I only with white hairs. The posterior margins of the tergites I-V have comparatively broad white fasciae, the black basal space being narrower than the bands, but on tergites II and III this space is somewhat wider laterally; pilosity on II and III decumbent. Middle tibiae and 1st and 2nd joint of the middle tarsi exteriorly with decumbent white hairs, hind tibiae and metatarsus III also with white hairs, the latter with black hairs at the upper (exterior) margin, and the white patch becoming much narrower towards apex. The hind margins of the sternites bear, at least laterally, white hairs.

Labrum only slightly transverse. Antennal 3 scarcely longer than broad, somewhat longer than 4. Cells of the hyaline wings only in r1 with a few microsetae. Nervulus prefurcal. Tergite VII with two small reddish teeth which are separated by a broad interval and are shorter than in *albigena*.

FEMALE : Length 10-11 mm. Antennae black, flagellum somewhat reddish below. Face white with two large basal spots of the clypeus that are fused with

(8) In cases where the segments of the abdomen are fully distended one may observe a narrow dark basal band in front of the white pilosity of the tergites even in species which have the pilosity extended to base; but in such cases the dark fascia is situated in front of the basal ridge of the segment, as e.g. in *A. byssina*. In *A. latizona* and *A. mucorea*, however, the pale hairs do not reach the basal ridge, except at the sides of the segments.

the dark sides of the frons; fore margin of clypeus broadly white, like a longitudinal conical median line extending basad to the frontal area which is dark or little white. Pilosity of the thorax as in the male, short, sometimes with yellowish tinge, and like the vertex well supplied with black hairs. Tergite I in the middle across with semi-erect black hairs, margins with raised white hairs. Abdominal fasciae very broad so that there remains only a narrow black basal space on tergites II and III that may be covered in specimens with contracted segments, but laterally the black is always visible at base, since the fasciae are somewhat convex in the middle; tergite V in the middle with black velvet-spot, as in *A. byssina*. Basal sternites often reddish-brown; hind margins with white fringe. Middle and hind tibiae exteriorly with white hairs, wholly covering matatarsus II; metatarsus III shows a roundish white basal hair-spot; the metatarsi are broad and narrowed towards apex.

Antennal 3 gradually widened towards tip, not quite three times as long as broad, and not longer than the three following joints together. Pubescence of wing as in the male. Clypeus in front medially with very fine and dense, laterally with coarser and more scattered puncturation. Tegulae testaceous, pubescent within.

HABITAT : Widely distributed (El-Mallah; Mansuriah, Gebel Asfar, Cairo, Meadi, Helouan, Wadi Hof; Fayed; Luxor. (May-September).

Anthophora byssina (Klug)

1812. Unnamed, Savigny, Description d'Egypte, pl. I, fig. 20 (female) ?
1845. *Saropoda byssina* Klug, Symb. phys., Dec. 5, Ins., pl. 50, fig. 4 (female).
1871. *Anthophora cana* Walker, List Hym. Egypt, p. 56 (male) ?
1897. *Podalirius byssinus* Friese, Bienen Europas, III, p. 106.
1899. *Podalirius schmiedeknechti* Friese, *Ent. Nachrichten* XXV, p. 323 ?
1916. *Anthophora byssina* Storey, Min. Agric., Techn. Bull. 5, p. 18.
1926. *Anthophora byssina* Alfken, *Senckenbergiana*, VIII, p. 101.

MALE : Length 8.5-10 mm. Black. Antennal 1 sometimes brownish or reddish beneath or with yellow dot at tip, never wholly yellow or white beneath, but with white hairs; flagellum black or at the most brownish beneath. Face white, though the ground is scarcely visible owing to the dense, short, white pilosity; vertex and thorax with snow-white hairs, without yellow tinge, on the propodeum this white pilosity is long, posteriorly far surpassing base of tergite I of abdomen; the latter tergite with almost decumbent, the tergites II-V with wholly decumbent, white pilosity, covering the disk to nearly the basal ridge and being somewhat denser at the hind margins in place of the fasciae; tergite VI with dark pilosity. Head and thorax below with white, sternites of the abdomen with short brownish, hairs, sides with some white fringe hairs. Middle tibiae and metatarsus II, as well as hind tibiae with adpressed white, metatarsus III on both faces with black, hairs, only at the base exteriorly sometimes with very few white hairs. Ground colour of tarsi and calcaria black.

Labrum moderately transverse. Antennal 3 short, scarcely longer than broad. Wings hyaline, longitudinal veins at base and costa yellowish, cells almost without pubescence. Nervulus distinctly prefurcal. Tergite VII with two ferruginous (but often blackened by the hairs) small teeth, with an almost straight marginal interval between them. Sternite VI more shining than the preceding sternites but distinctly punctured, without larger smoothening (as against *mucorea*).

FEMALE : 8.5-11 mm. Face white, at base black, clypeus with broad white fore margin and wedge-shaped median stripe, but the frontal area remains dark. Antennal 1 and flagellum mostly slightly reddish beneath, the former with white hairs beneath. Face with short, dense, white pilosity. Pilosity of head, thorax and abdomen as in the male, the 5th tergite with a large, black, about triangular velvet-spot in the middle. Sternites often reddish on the ground of the hairs, sides white-haired. Metatarsus III with black hairs only. Antennal 3 about three times as long as broad and about as long as the three following joints combined. Wings hyaline, costa wholly, the other longitudinal nervures at base, yellowish. Tegulae with white pubescence.

HABITAT: Common all over the country, all the year round.

Anthophora deceptrix spec. nov.

MALE : 8.5-9.2 mm. Black, only the ultimate tarsal joint reddish,sometimes all tarsi brown. Face (labrum, frontal area, mandibles and clypeus) yellow; sides of frons black, tips of mandibles reddish. Antennal joint 1 black, or with a small yellow dot or line near apex beneath. Flagellum not ferruginous. Face with dense and rather long, almost decumbent, hairs; vertex and thorax with raised grey-white pilosity, without black hairs, like the 1st tergite; the remaining tergites, inclusive of VI, with dense decumbent grey-white pilosity, the pale margins somewhat transparent. The whole middle and hind tibiae and tarsi exteriorly with adpressed white pilosity, metatarsus III only interiorly with black hairs. Under side of body in front clothed with raised white hairs. Calcaria yellow, margined with black. Wings hyaline, veins ferruginous at base, dark about the apical half; cells almost devoid of pubescence.

Labrum scarcely transverse, clypeus little protruding. Antennal 3 above scarcely 1.3 times as long as broad, joint 4 about square, 5 elongate. Tergite VII yellow at the apex, with two distinct small teeth separated by a flatly arched interval. Nervulus strongly prefurcal. Ultimate joint of middle tarsi slender.

FEMALE : Length 9-9.5 mm., width of head 3.7-3.8 mm. Clypeus at the fore margin for scarcely one-third of the length, yellow, in connexion with a wedge-shaped median line, scarcely reaching base; frontal area and sides of frons black, labrum and mandibles (with dark tips), yellow. Flagellum ferruginous below. Thorax with short raised grey pilosity, without black hairs, abdomen with dense grey pilosity and a large velvet-spot in the middle of tergite V. Tegulae testaceous. Wings hyaline,

veins testaceous in basal half, dark in apical half. Pubescence of cells visible only near the fore margin of cell m1 and somewhat in r1. Nervulus prefurcal. Middle and hind tibiae and middle tarsi exteriorly with decumbent white hairs, metatarsus III exteriorly for two-thirds with white, for the rest and interiorly with black, pilosity.

HABITAT : 1 male (holotype), Sinai, Tayiba, (30-31.v.1935), coll. ALFIERI; 1 male (paratype), Wadi Shagra, 24. iv. 1935 (leg. M. KASSIM, coll. Min. Agric.); 1 male, Kafr Hakeem, 14.vi.1933 (coll. Min. Agric.); 1 male, Helouan, x. (leg. and coll. H. PRIESNER).

The female described above most likely belongs to this species, though I saw only 1 specimen (Borgash, 8.v.1934, coll. Min. Agric.).

The species is very similar to *byssina*, but in the latter the 3rd metatarsus has only black hairs, the face is white (not yellow), tergite VI has only dark hairs and VII is not pale yellow. The male of *mucorea* has the base of the tergites narrowly black and is differing too by the dark tergites VI and VII, and the black metatarsus.

Anthophora torensis spec. nov.

FEMALE : 9-9.5 mm. Width of head 4 mm. Black, flagellum from joint 4 onwards ferruginous beneath. Clypeus at the fore margin and in the middle (broadly conically) yellow, the black base occupying at least half of the length; labrum and base of mandibles yellow, tips of the latter dark. Head in front with short, raised white, vertex and thorax with such more yellowish white, pilosity, tergite I in front and at the sides with raised, otherwise with decumbent dense grey pilosity, like the rest of the abdomen. Thorax with a few brown hairs between the pale ones; tergite II without raised hairs, III and IV with scattered semi-erect pale hairs, visible in profile. Apical margins of tergites slightly yellowish transparent beneath the pile; tergite V with black cushion of hairs in the middle. Middle tibiae with decumbent yellow-white hairs, apex with ferruginous adpressed tuft of hairs; metatarsus at the hind margin with somewhat longer whitish hairs, interiorly with brown hairs; hind tibiae with decumbent yellow-white hairs, metatarsus III at base with slightly raised yellow-white hairs, *but in the apical third with black hairs* like the remaining tarsal joints; interiorly the 3rd metatarsus bears blackish-brown hairs. Penicillus with rather fine short bristles. Wings hyaline, veins brown, pubescence of cells noticeable only in r1. Sternites in the middle with ferruginous, at the sides with white, fringe hairs, the disks with dark brown hairs mixed with pale hairs, all slightly raised.

Labrum moderately strongly transverse. Puncturation of the clypeus covered by the pilosity. Antennae short, joint 32.5 times as long as broad, little shorter than the three following joints together, 4 strongly transverse, the following joints about square. Nervulus strongly prefurcal.

HABITAT : 1 female (holotype), Sinai, El-Tor, 14.v.1934 (leg. H. PRIESNER, coll. Min. Agric.).

None of WALKER'S species described from Sinai agrees with this remarkable species.

Anthophora candidella spec. nov.

FEMALE : 6.6-7 mm. Width of head about 3 mm. Black, tarsal joints 2-5 dark brown; mandibles (with reddish tips), labrum, fore margin of clypeus and a median stripe reaching base, *white*; fore margin of clypeus for somewhat less than half of the latter's length, white. Flagellum brownish below. Face in front with almost decumbent, above with raised, pure white pilosity; thorax and tergite I with raised, the other tergites with decumbent, very dense, white pilosity; tergite II with a few raised white hairs, visible in profile, on the remaining tergites raised hairs are fewer yet and inclined, not vertical; tergite V with black velvety spot at the hind margin. Under side of anterior body with raised white hairs, sternites of the abdomen black, with margins somewhat paler, transparent, and with *black hairs on the disks*, some white fringe hairs at the sides. Tegulae testaceous, somewhat pubescent. Wings hyaline, without pubescence in the cells, nervures yellowish at base, brown in the distal part.

Labrum strongly transverse. Clypeus densely punctured. Antennal joint 3 (black) not quite twice as long as broad, longer than the two, but shorter than the three, following joints together. Nervulus distinctly prefurcal.

HABITAT : 1 female, Mansuriah, 23.iv.1954, holotype, in coll. Ain-Shams University.

Although I only known a unique specimen this species had to be described, since it can easily be recognized again, being rather characteristic.

Belonging to the smallest forms, like *nivosella*, it differs from this species by the shorter pilosity of the legs, the white, instead of pale yellow, face, the dark pilosity of the sternites and the still smaller size. In the other very small grey species the nervulus is not so distinctly prefurcal, the colour of the pile not so pure white, the pilosity less dense, and the metatarsus 3 is interiorly clothed with ferruginous hairs.

Anthophora nivosella spec. nov.

MALE : 8 mm. Black, middle and hind tarsi with joints 2-5 ferruginous to brownish, tip of joint 5 darkened. Flagellum below ferruginous to pale brown. Face whitish, tips of mandibles testaceous, clypeus in front for a little more than half of its length, and antennal joint 1 beneath, white. Face with long and dense, almost decumbent, white pilosity. Thorax and abdominal tergite I, the latter with particularly long, raised white hairs, the remaining tergites with very dense, adpressed white

pilosity; tergite II also with scattered long pale raised hairs, seen in profile. Sternites of the abdomen with yellowish transparent margins, at the sides with some white fringe hairs, in the middle of sternite IV with very fine, short, testaceous tomentum. Legs exteriorly with decumbent white pilosity, the hind margins of the femora, tibiae and tarsi with rather long raised white hairs; all tarsal joints exteriorly with white hairs, metatarsus III interiorly with dark brown hairs. Wings hyaline, nervures yellow, somewhat brownish towards apex of wing, cells bare.

Clypeus somewhat protruding, labrum transverse. Antennal 3 scarcely longer than broad, longer than 4, but somewhat shorter than 5. Nervulus distinctly prefurcal. Joint 5 of middle tarsus *slender*. Tergite VII ferruginous apically, with median carina and ending in two small broadly triangular teeth which are separated by an obtusely angled excision.

Female : Length 7.5-8.5 mm. Width of head 3.3-3.4 mm. Black, legs sometimes dark brown, tarsal joints of middle and hind legs testaceous to pale brown. Flagellum wholly or only below ferruginous, mostly from apex of joint 3 onwards. Face pale yellow, i.e. mandibles (tips reddish), labrum, almost apical half of clypeus and a median line of it that may reach the base; the fine fore margin of the clypeus lined with brown; frontal area usually dark. Face with almost adpressed, vertex and thorax with short raised, tergite I with partly raised and partly decumbent, *white* pilosity; the remaining tergites with very dense decumbent white pilosity, tergite V with large black velvet-cushion. Sternites shining, brownish, with yellowish transparent margins, little hairy, at the sides with some whitish, in the middle with ferruginous, fringe hairs. Fore femora with long white hairs. Tibiae and tarsi exteriorly with white hairs, metatarsus II at the hind margin with white hairs, on the disk which is rather dark, with few white hairs. Metatarsus III interiorly with *dark brown to black* hairs. Tegulae pale, transparent. Wings hyaline, veins yellow, terminal crossveins brownish. Calcaria yellow.

Labrum strongly transverse, very coarsely rugose. Clypeus convex, especially in the middle slightly raised. Antennae short, joint 3 only 1.5 times as long as broad or scarcely more, distinctly shorter than the three following joints together, little longer than 4 and 5 combined. Wing cells bare. Nervulus distinctly prefurcal.

Habitat : Kerdasa, Abu Rowash, Wadi Rishrash (May-June).

The female is quite similar to *A. tenella* (Kl.) but certainly specifically different by the very dense white pilosity of the tergites, the 3rd metatarsus which is interiorly clothed with dark hairs, the almost wholly yellow wing veins and the distinctly prefurcal nervulus. In habitus and pilosity it is closer yet to *A. candidella* in which, however, the sternites of the abdomen are set with blackish hairs and the pale parts of the face are white.

I am not yet sure whether the male described above really belongs to this species, since the colour of the pale parts of the face is white, while in other respects it better agrees with this species than with *candidella*. More material will be required to clear up this question.

Group VIII (tarsalis)

Anthophora tarsalis spec. nov.

MALE : 9.5-10 mm. Black, femora and tibiae reddish-brown, apices of tibiae ferruginous, like all metatarsi. Antennal joint 1 beneath, frontal area, clypeus and labrum white, clypeus with black lateral stripe at the suture to the sides of the frons; labrum with two small reddish dots at base, mandibles ferruginous, base and tips darker. Flagellum dark. Pilosity of frons dirty white, of vertex white and black mixed like the thorax. Tergite I almost only with raised whitish-yellow hairs, tergites II-V with moderately long, raised, chiefly black hairs, fasciae of attached white hairs present on the broadly yellowish transparent hind margins of tergites I-VI. Under side with long whitish hairs, anterior sternites with longer, posterior with short, whitish pilosity and a velvet-black double spot on tergite IV medially; the following sternites nearly smooth, reddish, with a transverse arched fovea on VI. Wings hyaline, veins black, cells m1, r1 and sc with some pubescence at the fore margin. Nervulus prefurcal. Pilosity of the hind tibiae and metatarsus III almost decumbent, yellow-white. The metatarsus II at the apex with somewhat longer, whitish pilosity, exteriorly at the apex with a small black fan. Calcaria yellow.

Clypeus protruding, shining, extremely finely and rather sparingly punctured. Labrum little punctured, smooth, square. Genae wanting. Antennae slender, joint 3 about 2.5 times as long as broad. Anterior metatarsus slightly club-shaped, middle metatarsus long, slender, at least as long as the tibia, the remaining tarsal joints together longer than the metatarsus of the tibia, joint 5 blackened, with black hairs on both sides (weak brush). Hind legs quite peculiar: hind coxae with long, fine tooth, trochanters with hump; femora simple, posterior face smooth and shining; hind tibiae much widened towards apex, at the end with a blunt interior hump; metatarsus broad, widened towards apex and with triangular tooth, exterior margin of metatarsus convex towards apex and set with bristles; joints 2-5 of the hind tarsi very long, joints 2-4 of about equal length, 2 somewhat thicker than the following joints, joint 5 about 1.5 times as long as each of the preceding three; the whole tarsus almost three times as long as the tibia (apical tergite damaged).

FEMALE : 9-11 mm. Quite different from the male. Black, legs pale brown to ferruginous, tips of tibiae mostly and tarsi ferruginous. Antennae dark, flagellum below at most dark brown; face black, clypeus with narrow white median stripe that sometimes reaches base, frontal area dark or slightly reddish; in front, the clypeus is only in the middle somewhat triangularly whitish; labrum white, at the sides more or less broadly margined with brown. Mandibles reddish-brown. Face with moderately dense, short, raised dirty pilosity, on the vertex the hairs are mixed with black ones. Thorax with very short yellow-white hairs, mixed with black hairs. Tergite I with raised, whitish-yellow-grey hairs, the following tergites densely clothed with almost decumbent comparatively thick, nearly scale-like grey hairs between

which there are scattered, raised, moderately long *brownish* hairs. Tergite V with a dark brown median cushion, at the sides with longer, whitish hairs. Fasciae are not developed but the narrow transparent pale margins suggest bands which are somewhat broader in the middle and at the extreme sides, narrower at the two intervals. Sternites reddish on the ground, at the sides with whitish fringe. Tibiae and metatarsi with slightly raised whitish hairs.

Labrum about square, angles rounded. Clypeus with somewhat transversely rugose sculpture in front, the rest covered by the pile. Antennal joint 3 somewhat more than three times as long as broad, little longer than the three following joints together. Wings as in the male.

HABITAT : Wadi Ambaga near Kosseir (male and female; types); Bir Abrag (South Eastern Desert), leg. *Selim Farag* (coll. Min. Agric.).

The species is unmistakable by the characteristically formed and extremely long middle and hind legs of the male, and obviously belongs near *A. gracilipes* F. Mor., but differs from it in details of the structure of the legs.

APPENDIX

1. DESCRIPTIONS OF SPECIES WHICH REMAINED UNKNOWN TO THE AUTHOR

Anthophora kneuckeri Alfken

1938. *Anthophora kneuckeri* Alfken, *Deutsche Entom. Zeitschr.*, p. 427 (female).

ALFKEN describes (in German) the species as follows: "Female 8.5 mm. Black. Mandibles red in the middle. Genae linear, red at base. Labrum somewhat broader than high, shining, coarsely rugosely punctured, red, only the exterior angles black and with raised white hairs. Clypeus strongly convex, on the disk more sparingly and coarsely, in front more densely and finely, punctured, with distinct median carina and brown-red fore margin. Frons, vertex and temples with long raised white pilosity; vertex with some intermixed black hairs, at the sides densely and finely punctured. Antennal joint 1 at extreme apex annulated with testaceous; flagellum below at middle dark red-brown. Thorax and propodeum dorsally with grey, ventrally with white, hairs; mesonotum with many black hairs mixed with the pale hairs. Sculpture not visible owing to the dense pile. Tergites of abdomen very densely and finely punctured. Hind margins of tergites I-IV with dense, decumbent white fasciae, the posterior ones broadest, those of II-IV somewhat produced. Tergite I at base with raised grey-white hairs. Tergite V with brown-black apical fringe, at the sides with raised white pilosity. Sternites slightly shining, extremely finely and densely granulated and, besides, with scattered punctures, hind margin somewhat pale

transparent, thinly set with white fringe. Legs entirely with white pilosity. Scopa of tibiae white, calcaria ferruginous. Metatarsus III exteriorly clothed with loose white hairs, penicillus black, patella red. Tarsi ferruginous. Wings slightly shaded, veins and pterostigma black-brown, tegulae brown-red".

HABITAT : 1 female, Sinai (leg. A. KNEUCKER).

ALFKEN hints at that this species may be identical with the poorly described *A. pauperata* Walker.

Anthophora combusta Dours

1869. *Anthophora combusta* Dours, Icon. Anthoph., p. 188 (female).
1897. *Podalirius combustus* Friese, Bienen Europas, III, p. 291.

Description translated (from French) : "Black; antennae ferruginous below, except the first three joints which are black; clypeus finely punctured, black, except a dot between the antennae, the inferior portion, and part of the cheeks (sc. sides of frons) which are yellow; besides, there is a raised line on its middle; labrum finely punctured, yellow-ferruginous towards its inferior two-thirds, black towards the upper end (sc. base) where there are two small tubercles; mandibles yellow-ferruginous, black at tips; hairs of face, vertex and thorax black, mixed with red. Abdominal segments clothed with decumbent ferruginous hairs, except on the upper third of the 1st segment where they are black. Beneath, the segments are blackish ferruginous and fringed with ferruginous hairs. Hairs of legs black, long, coarse. Wings infumated; margin, veins black. — Length 14 mm.". — Egypt.

Anthophora cinerascens Lep.

1841. *Anthophora cinerascens* Lepeletier, Hist. nat. Ins. Hym., II, p. 51 (female).

Description translated (from French) : FEMALE: "Black, labrum (having a ferruginous dot on either side of base) and clypeus (with a rather small nearly square spot on either side of base, and the lower margin, black) yellowish-white, somewhat ferruginous. Hairs of head and thorax cinereous, perhaps somewhat red on the dorsum when alive. Hairs of 1st abdominal segment raised; 2nd and 3rd segments covered with decumbent cinereous hairs, the inferior margin of these three segments bearing a narrower fascia of denser and more whitish decumbent hairs; hairs of 4th and 5th segments black and raised, those of the sides longer, white; lower margin of 5th segment and sides of the anus clothed with brown-ferruginous hairs; fringe of under side of segments dirty white. Legs brown-ferruginous. Hairs of upper side of legs cinereous, those of under side black on the tibiae, blackish-ferruginous on the tarsi. Wings transparent, veins and margins brown. .. Nubia".

This species does not agree with any Egyptian one described in this paper. Its interpretation is rendered more difficult yet, because no measurements are given by LEPELETIER .

Anthophora nigrilabris Spin.

1838. *Anthophora nigrilabris* Spinola, *Ann. Soc. Ent. France*, VII, p. 543 (female).
1896. *Podalirius saropodoides* Dalla Torre, Catal. Hym., X, p. 288.
1897. *Podalirius saropodoides* Friese, Bienen Europas, III, p. 108.

Original description (from French) : FEMALE: "Antennae, body and legs black; clypeus, labrum and mouth parts of the same colour; head and thorax covered with raised, in general cinereous, hairs, fulvous only on the mesothoracic dorsum. Tergite I covered likewise with raised whitish or cinereous hairs; the following segments nearly smooth having some hairs only here and there : three large bands of white hairs, somewhat woolly, decumbent in various directions on the hind margins of segments II-IV; V black with fine white margin; VI covered with white woolly hairs. Venter little hairy; black hairs on the disks of the segments; marginal fringe whitish. Legs black-haired; everywhere with cinereous hairs, except on the 1st joint of the hind tarsi where they are white at the anterior (sc. exterior), fulvous on the posterior (sc. interior) face and black at the apical appendage. Wings hyaline; veins black. — Length 7 lines, width 3 lines. — Male unknown. — I presume that this female is represented by fig. 10, pl. I of Descr. d'Egypte. No details are drawn, and one cannot see the front of the head, but it is just this what makes me believe that it is entirely black".

I do not think that SAVIGNY'S illustration (pl. I, fig. 10) refers to SPINOLA'S species; the former might well be identical with *A. blanda* Pér. which is certainly a smaller species. I do not know any Egyptian species that would agree with *nigrilabris* Spin. (l.c., p. 543 nec p. 546); there is no proof either for that it is really Egyptian, except for SPINOLA'S reference to SAVIGNY'S figure.

2. WALKER'S NOT YET INTERPRETED SPECIES OF EGYPTIAN ORIGIN

WALKER reports in his "List of Hymenoptera collected by J.K. Lord in Egypt, etc.", 1871, p. 55, the occurrence in Egypt of the following species:

Anthophora basalis Smith from Sinai. This species is South African; *A. dubia* Smith, which is according to Friese identical with *A. gallica* DT. and Fr. (cf. FRIESE, Bienen Europas, III, p. 139-140), from Cairo and Heliopolis. This species has not been found again; *A. nigrocincta* Lep. (cf. FRIESE, l.c., p. 204) from Cairo and Heliopolis; this species too is not represented in Egyptian collections. It seems to me that it is preferable to assume a confusion of labels or wrong identification than to list these species as Egyptian before they have not been collected again in this country.

Moreover, WALKER described (l.c., 1871) a series of at that time new species which have either not yet been found again or cannot be interpreted owing to the inadequacy of the descriptions. Since the paper in question is difficult to obtain I am copying these descriptions, as follows.

Anthophora annulifera Walker (l.c., p. 55) : "Female : Black. Head, pectus and legs with white hairs. Head above yellow, excepting the vertex. Eyes lurid. Mouth tawny. Antennae dark red beneath; first joint pale testaceous beneath. Thorax with yellowish hairs. Abdomen with a band of white pubescence on the hind border of each segment. Legs with black hairs beneath. Wings cinereous ; veins black. Length of the body 5 lines. Wady Ferran".

Anthophora leucomelaena Dalla Torre (= *melaleuca* Walker, l.c., p. 56) : "Female : Black. Head, thorax, pectus and legs thickly clothed with snow-white hairs. Eyes reddish. First joint of antennae whitish beneath. Abdomen with snow-white pubescence and with four deep black bands, which from the first to the fourth are successively narrower. Legs clothed with black hairs beneath. Wings pellucid;, veins black, testaceous at the base. Length of the body 4 1/2 lines. Cairo." May, yet be a specimen of *A. byssina* with abdominal segments distended. The white colour of antennal 1 may refer to its pilosity.

Under the name of *leucomelaena* DT. ALFKEN described (*Ent. Mitt.*, XVI, p. 151, 1927) a male from Port Sudan. He does not compare this specimen with other similar species but just says that *A. andresi* Fr. might coincide with it. However it could not be identical with *A. andresi* Fr. since in the former the face is yellow, not white. WALKER'S species cannot be identical with *A. andresi* either, because the wing veins are described as testaceous at the base in WALKER'S *melaleuca* = *leucomelaena* DT.

Anthophora lutescens Walker (l.c., p. 56) : "Female : Black, clothed with luteous hairs. Hind part of the head with cinereous tomentum. Face and clypeus yellow. Eyes lurid. Antennae piceous, red beneath; first joint piceous, whitish beneath. Pectus with hoary hairs. Abdomen with a testaceous band along the hind border of each segment. Four posterior tibiae densely pilose. Wings cinereous; veins black, tawny towards the base. Length of the body 4 lines. Wady Ferran".

Anthophora pauperata Walker (l.c., p. 57) : "Female : Black. Head, thorax, pectus and legs with cinereous hairs. Eyes piceous. Mouth tawny. Antennae tawny beneath. Abdomen with a hoary testaceous-bordered pubescent band on each dorsal segment. Legs with black hairs beneath. Wings cinereous; veins black. Length of the body 5 lines. Mount Sinai".

Anthophora illepida Walker (l.c., p. 57) : "Female : Black. Head, thorax, pectus and legs with cinereous hairs. Face and clypeus prominent, forming a transverse ridge. Eyes piceous. Abdomen with a pale luteous band on the border of each segment. Tibiae and tarsi partly clothed with luteous hairs. Wings cinereous; veins black; tegulae tawny, large. Length of the body 6 lines. Wady Ferran".

Anthophora pulverea Walker (l.c., p. 57) : "Female : Black. Head, thorax, pectus and the tibiae and tarsi of the four anterior legs with white hairs. Face and clypeus yellow, the former divided from the latter by a slight transverse ferruginous ridge. Mouth ferruginous. Eyes red. Antennae red beneath. Abdomen with a broad band of white pubescence along the hind border of each dorsal segment. Hind tibiae

beneath and hind tarsi with black hairs, the former with bright ochraceous hairs above. Wings cinereous; veins black. Var. b. Hind tibiae with yellowish white hairs above. Length of the body 5 lines. Wady Hebran".

Anthophora superans Walker (l.c., p. 58). "Female. Vertex, thorax, pectus and base of abdomen thickly clothed with pale ochraceous hairs. Head excepting the vertex white and without hairs. Eyes and mouth ferruginous. First joint of the antennae white beneath. Abdomen with three bands of pale ochraceous pubescence on the hind border of the segments. Legs fringed with cinereous hairs; tibiae and tarsi clothed with cinereous pubescence; tarsi with ochraceous hairs beneath. Wings slightly cinereous; veins black. Length of the body 7 1/2 lines. Mount Sinai".

3. A LIST OF SPECIES OF NEIGHBOURING COUNTRIES

Some of the species of neighbouring countries, especially those from Libya and the northern Sudan are likely to occur in Egypt too. The student is therefore advised to also consult the descriptions of the species alphabetically listed below, in cases of discovery of forms which do not agree with the species described in this paper.

aflabellata Gribodo (in Zanon, *Mem. Acc. Nuovi Lincei* (2) VIII, p. 69, 1926; Bengasi), *agama* Radoszkowsky (FRIESE, Bienen Europas, p. 177; Algeria), *albescens* Dours (FRIESE, l.c., p. 64; Algeria), *albicilla* Pérez (FRIESE, l.c., p. 224; Cockerell, *Ann. Mag. Nat. Hist.* V. (9), p. 114, 1920; Algeria), *albocinerea* Saunders (*Trans. Ent. Soc. London*, p. 268, 1908; Biskra), *ambigua* Pérez (FRIESE, l.c., 183; Algeria), *arietina* Dours (FRIESE, l.c., p. 172; Algeria), *atroalba* Lep. (FRIESE, l.c., p. 250; Algeria), *bimaculata* Panz. (FRIESE, l.c., p. 102; Algeria), *bisulca* Pérez (FRIESE, l.c., p. 209; Algeria), *calcarata* Lep. (FRIESE, l.c., p. 158; ALFKEN, *Mitt. D. Ent. Ges.*, III, p. 123, 1932; Algeria, Tunisia), *caroli* Pérez (FRIESE, l.c., p. 98; Algeria), *doursiana* Friese (l.c., p. 292; Algeria), *dusmeti* Guiglia (*Ann. Mus. Genova*, LVI, p. 131, 1933; Cyrenaica), *erschowi* Fedtsch. (FRIESE, l.c., p. 252; GRIBODO, *Boll. Mus. zool. Torino*, XXXIX, p. 9, 192, Libya), *farinosa* Klug (Symb. phys., pl. 50, fig. 2, 1845; Arabia), *fastuosa* Gribodo (l.c., p. 13; Libya), *ferruginea* Lep. (FRIESE, l.c., p. 131; Algeria), *festae* Gribodo (l.c., p. 16; Libya), *fratercula* Gribodo (l.c., p. 7; Libya), *ghigii* Gribodo (l.c., p. 14; Libya), *guigliae* Dusmet (*Ann. Mus. Genova*, LIII, p. 314; Libya), *holoxantha* Pérez (FRIESE, l.c., p. 297; Algeria), *intermixta* Gribodo (l.c., p. 11; Libya), *intricata* Gribodo (l.c., p. 10; Libya), *libyphaenica* Gribodo (l.c., p. 13; FRIESE, l.c., p. 300; Algeria, Libya), *marqueti* Pérez (FRIESE, l.c., p. 91; Algeria), *nigrociliata* Pérez (FRIESE, l.c., p. 303; Algeria), *nigrocincta* Lep. (FRIESE, l.c., p. 204; Algeria), *nigropilosa* Friese (l.c., p. 99; Algeria), *planca* Pérez (FRIESE, l.c., p. 164; Algeria), *quadricolor* Er. (FRIESE, l.c., p. 140; Algeria), *retusa* L. (FRIESE, l.c., p. 243; Algeria), *rivolettii* Pérez (FRIESE, l.c., p. 183; Algeria), *romandi* Lep. (FRIESE, l.c., p. 228; Algeria), *talaris* Pérez (Friese, l.c., p. 79; Algeria), *valga* Klug (Symb. phys., pl. 49, fig. 3, 1845; Arabia), *ventilabris* Lep. (FRIESE, l.c., p. 207; Algeria), *vetula* Klug (Symb. phys., pl. 49, fig. 3, 1845; Arabia).

INDEX

Aegyptiaca 9, 25, 26, 28; *aegyptorum* 7, 18, 30; *aflabellata* 114; *afra* 14, 21, 98; *agama* 36, 114; *albescens* 114; *albicilla* 114; *albigena* 15, 98; *albocinerea* 114; *albosignata* 8, 18, 25, 38; *alfierii* 12, 18, 25, 52; *alfkenella* 10, 21, 22, 76; *alternans* 13, 20, 81; *ambigua* 53, 54, 114; *andresi* 15, 19, 94; *annulifera* 98, 113; *arabica* 16, 44; *arietina* 114; *armata* 87; *atriceps* 7, 12, 25, 27, 43; *atricilla* 30; *atroalba* 114; *basalis* 112; *bicincta* 83; *bimaculata* 114; *bisulca* 114; *blanda* 11, 20, 60; *boops* 11, 82; *borgensis* 11, 27, 58; *byssina* 14, 15, 22, 104; *calcarata* 46, 58, 59, 114; *cana* 104; *candidella* 24, 107; *canescens* 42; *carnea* 11, 17, 88; *caroli* 39, 114; *cinerascens* 111; *cinerea* 46; *cinereiceps* 7, 16, 26, 41; *clavatipes* 11, 17, 56; *combusta* 111; *concinna* 9, 24, 74; *concolor* 17, 84; *crassipes* 11, 28; *crocea* 13, 22, 89; *cunicularia* 55; *deceptrix* 15, 23, 105; *desertorum* 8, 27, 45; *dispar* 8, 26, 33; *disparilis* 7, 26, 35; *doursiana* 114; *dubia* 112; *dusmeti* 114; *elbana* 10, 64; *erschowi* 114; *erubescens* 88; *extricata* 17, 28, 55; *facialis* 7, 12, 25, 47; *fallaciosa* 10, 70; *farinosa* 14, 19, 90, 91, 114; *fastuosa* 114; *fayoumensis* 9, 13, 16, 24, 64; *ferruginea* 114; *festae* 114; *flabellata* 9, 18, 50; *flaviceps* 97; *fratercula* 114; *fulvitarsis* 28; *fulvitecta* 81; *fulviscopa* 78; *fulvodimidiata* 9, 19, 21, 77; *fumipennis* 17, 86; *galalensis* 22, 78; *gallica* 112; *glauca* 94, 95; *ghigii* 114; *gracilipes* 110; *guigliae* 27, 114; *hegasica* 9, 24, 75; *helouanensis* 15, 16, 63; *hispanica* 12, 18, 25, 52; *holoxantha* 114; *humilis* 23, 67, 68; *illepida* 113; *inclyta* 11, 18, 80; *intermixta* 114; *intricata* 114; *klugi* 14, 19, 90; *kneuckeri* 20, 110; *lanata* 7, 16, 26, 42; *latizona* 15, 21, 103; *leucomelaena* 113; *libyphaenica* 114; *litorana* 14, 93; *lutescens* 113; *lutulenta* 10, 24, 61; *maculigera* 10, 85; *magnilabris* 14, 92; *marqueti* 114; *melaleuca* 113; *mellina* 9, 13, 22, 73; *montivaga* 16, 20, 21, 100; *moricei* 17, 27, 56; *mucida* 8, 18, 25, 37; *mucorea* 15, 16, 20, 21, 22, 101; *nasuta* 28; *nigrilabris* 41, 42, 111; *nigripes* 77; *nigripilis* 17, 27, 57; *nigrociliata* 114; *nigrocincta* 112, 114; *nigropilosa* 114; *niveiventris* 27, 36; *niveohirta* 34; *nivosella* 15, 24, 107; *nubica* 12, 17, 85; *omissa* 19, 95; *oraniensis* 12, 25, 79; *orientalis* 42; *pauperata* 113; *perlustrata* 10, 71; *pipiens* 16, 21, 99; *planca* 114; *pretiosa* 7, 32; *priesneri* 11, 28, 57; *pulverea* 103, 113; *punctifrons* 14, 20, 97; *quadricolor* 114; *quadrifasciata* 14, 19, 92; *retusa* 29, 114; *rivolettii* 54, 114; *robusta* 36; *rogenhoferi* 46; *romandi* 47, 114; *salviae* 99; *saropodoides* 42, 111; *savignyi* 14, 20, 96; *schmiedeknechti* 104; *scopipes* 8, 18, 47; *selecta* 23, 69; *semirufa* 10, 18, 78; *senescens* 8, 26, 29; *senilis* 28; *shagrensis* 23, 66; *sicheli* 44; *speciosa* 8, 26, 34; *spinipes* 60; *spinolana* 8, 18, 26, 49; *stschurowskyi* 30; *superans* 114; *talaris* 114; *tarsalis* 10, 23, 109; *tenella* 15, 24, 61, 67; *tenuiciliata* 8, 12, 18, 25, 39; *tetra* 12, 18, 87; *torensis* 22, 106; *tridentata* 74; *tridentella* 13, 23, 71; *valga* 11, 114; *ventilabris* 114; *vetula* 12, 114; *vidua* 17, 83; *wagneri* 81, 82; *wegelini* 17, 27, 53; *wegeneri* 81; *zanoni* 58.

ÜBER EINIGE SELTENE ORTHOPTEREN AUS ÄGYPTEN

(2. Teil)

von Dr. R. EBNER, Wien.

Als eine Art Fortsetzung meines früheren Artikels in dieser Zeitschrift (XL, 1956, pp. 11-20) bringe ich hier wieder einige für Ägypten interessante Arten. Auch dieses Material verdanke ich meinem Freund Prof. Dr. H. PRIESNER. Fast alle Exemplare befinden sich in staatlichen wissenschaftlichen Sammlungen in Ägypten.

Für die Mithilfe bei der Determination von 2 Acridiern bin ich Herrn Dr. V.M. DIRSH (London) sehr zu Dank verpflichtet.

GRYLLIDAE

Acheta palmetorum (Krauss)

Abu Rowash bei Kairo (libysche Wüste), 2.ii.1955, Entomology Dept., Faculty of Science, Ein Shams University, 1 Weibchen.

Durch die Aderung des Seitenfeldes der Elytren am ehesten hieher gehörig. Da nur 1 Weibchen vorliegt, ist die endgültige Bestimmung vielleicht besser bis zur Vorlage eines Männchen zu verschieben.

Die Art wurde aus Algerien beschrieben (KRAUSS, 1902), sie ist auch aus Marokko und Tunesien bekannt (CHOPARD, 1943). Sonstige Verbreitung: Malta (Valletta, 1955), Siwa Oasen (UVAROV, 1943), Zentral-Afrika: Ruanda Territorium (CHOPARD, 1926 und 1934), Turkana, Kenya, Somalia (CHOPARD, 1954).

Engryllodes kerkennensis (Finot) = macropterus (Fuente)

FINOT, *Bull. Soc. ent. France*, LXII, 1893, p. CCLII (*Gryllodes kerkennensis*), Weibchen.

FUENTE, *Act. Soc. Espan.*, XXII, 1894, p. 137 (*Gryllodes macropterus*), Männchen und Weibchen.

BOLIVAR, *Act. Soc. Espan.*, XXIII, 1896, pp. 47, 48 (*Gryllodes macropterus*), Männchen und Weibchen.

FINOT, *Ann. Soc. ent. France*, LXV, 1896, p. 596 (*Gryllodes kerkennensis*), Männchen und Weibchen. — Algerien und Tunesien.

BOLIVAR, *Ann. Sci. nat. Porto*, V, nr. 3, 1898; Cat. sin. Ort. Fauna ibér., Coimbra 1900, pp. 100, 101 (*Gryllodes macropterus*).

KRAUSS, *Verh. zool.-bot. Ges. Wien*, LII, 1902, p. 252-253 (*Gryllodes kerkennensis* und *finoti*), Männchen und Weibchen. — Algerien.

KIRBY, Synon. Cat. Orthopt. II, 1906, p. 40 (*Gryllodes*).

UVAROV, *Horae Soc. ent. Ross.*, XL, 1912, p. 41 (*Gryllodes macropterus* ?), Männchen und Weibchen. — SEMENOV, *Rev. Russe d'Entom*, XV, 1915, p. 30. (*Gryllodes dulcisonans=macropterus* Uv., non Fuente), Männchen und Weibchen. — Transkaspien.

CHOPARD, *J. Bombay nat. Hist. Soc.*, XXVII, 1921, p. 58 (*Gryllodes macropterus*), Männchen und Weibchen. — Mesopotamien.

CHOPARD, *Ann. nat. Hist.* (9), XIX, 1927, p. 255 (*kerkennensis* Finot "micropterous form" von *macropterus*).

BOLIVAR, *Bol. Soc. espan. Hist. nat*, XXVII, 1927, p. 103 (*Gryllodes* (*Gryllodinus*) *kerkennensis*) (*macropterus*, synonym mit *kerkennensis*).

TARBINSKY, *Bull. Inst. for controlling Pest and Diseases*, nr. 1, 1931, p. 160 (*Gryllodes macropterus*) (russisch). — URSS.

UVAROV, *P. Linn. Soc. London*, Session 155, 1942-43, Pt. 1, 1943, p. 20 (*Eugryllodes kerkennensis*), Männchen und Weibchen. — Siwa.

CHOPARD, Faune Empire franç., I, Orth. de l'Afrique du Nord, Paris, 1943, p. 191, f. 304, Männchen und Weibchen.

MORALES AGACINO, *Eos*, XX, 1944 (1945), p. 323 (*Eugryllodes kerkennensis*); *ibid.*, XXIII, 1947, p. 256 (*Eugryllodes kerkennensis*), Männchen. — Westl. Sahara: Rio de Oro.

Borg El-Arab (westlich von Alexandrien, mediterran), 20. iii. 1956, Entomology Dept., Faculty of Science, Ein Shams University, 1 Weibchen.

Körperlänge 18.5 mm., Pronotum 3 mm., Elytren 7.5 mm., Hinterschenkel 11 mm., Ovipositor 6.5 mm.

Ich benütze die Gelegenheit, um Literatur, Synonymik und Verbreitung der Art ausführlich anzugeben.

Aus Tunesien und Spanien beschrieben. Sonst noch : Rio de Oro, Algerien, Siwa, Cypern, ganze eremische Region, Mesopotamien, Irak, Arabien, URSS, Transkaukasien, Nord-Kaukasus, Transkaspien.

ACRIDIDAE

Duroniella lucasi (Bol.)

Borg El-Arab (westlich von Alexandrien, mediterran), 20. viii. 1955, Entomology Dept., Faculty of Science, Ein Shams University, 1 Männchen.

Verbreitung der Art : Marokko bis West-Asien.

Sphingonotus theodori theodori Uvar.

Wadi El-Lega, S. Sinai, 24.viii.1941, Entomology Department, Faculty of Science, Cairo University, Coll. EFFLATOUN and SHAFIK, 1 Weibchen.

Apical part of the second branch of median vein gives off 3 branches, intercalary vein straight (Benennung nach MISTSHENKO, 1936). Basaldrittel der Elytren deutlich braun und nach aussen scharf abgesetzt.

Zum Vergleich standen mir 2 Weibchen meiner Sammlung von Baalbek in Syrien (det. UVAROV, 1931) und Sinai (det. MISTSHENKO, 1934) zur Verfügung.

Bekannte Verbreitung : Kleinasien, Palaestina, Sinai, Syrien, S.W. Iran.

Mit einigem Zweifel stelle ich 1 Männchen vom selben Fundort, aber mit einem anderen Datum (4.ix.1941) hieher. Etwas dunkler als das Weibchen. Prozona des Pronotums fast ohne Kiel. Apikaler Teil des zweiten Astes der Media nur mit 2 Ästen. Hinterschenkel innen im basalen Teil braun, dann etwas aufgehellt, daran schliesst sich ein schwarzer Ring, vor dem Knie wieder sehr hell. Hinterflügel farblos. In der Färbung der Elytren etwas an *S. pictus* Wern. erinnernd.

Sphingonotus vosseleri Krauss

MISTSHENKO, *Eos*, XII, 1936, pp. 84, 178.

Wadi El-Lega, S. Sinai, 7. viii., Entomology Department, Faculty of Science, Cairo University, Coll. EFFLATOUN, 1 Männchen.

Kleine Art. Prozona des Pronotums mit einem deutlichen kleinen Kiel. Elytren nicht scharf gezeichnet. Apikaler Teil des zweiten Astes der Media mit 1 Abzweigung, Schaltader distal leicht geschwungen. Innenseite der Hinterschenkel gelb, distal mit undeutlicher dunkler Querbinde.

Zum Vergleich standen mir 4 sicher determinierte Weibchen (Museum Wien und meine Sammlung) zur Verfügung.

Verbreitung der Art : Algerien, Tunesien, Ägypten, Mesopotamien, Arabien.

Crinita nigripes (Uvar.)

UVAROV, Ergebn. Sinai-Exped. 1927, Leipzig 1929, p. 94, f. 2,3 (*Thalpomena hirtipes nigripes*), Männchen.

DIRSH, *Trans. ent. Soc. London*, C, 1949, p. 391, f. 114, 116, 118, Männchen.

Wadi El-Lega, S. Sinai, 20.viii.1941, 1 Männchen und 1 Weibchen.

Wadi El-Arbaain, S. Sinai, 31.viii.1938, 1 Weibchen.

An den Elytren gibt der apikale Teil des zweiten Astes der Media beim Männchen 2, beim Weibchen 3 Äste ab; Interkalar-Ader deutlich geschwungen. Hinterflügel an der Spitze nicht angeraucht.

	Männchen	Weibchen
Körperlänge	16 mm.	20 mm.
Pronotum	3 mm.	4 mm.
Elytren	17.5 mm.	20-21.5 mm.
Hinterschenkel	8.5 mm.	10 mm.

Die Art war bisher nur nach 1 Männchen vom Katherine Kloster (Sinai) bekannt.

Egnatioides sp. (det. DIRSH)

Wadi El-Arbaain, S. Sinai, 31.viii.1938, Zool. Dept. Collection, Egyptian University, 1 Weibchen.

Zu diesert Art schrieb mir DIRSH: "The small one is *Egnatioides* sp. ? and a possible new one, but it is difficult to decide on the basis of a single female. At any rate it is near to the *Egnatioides pasquieri* Morales, but differs by the sculpture of pronotum (see figure of the male in my syrian paper, 1950)".

Die genannte Arbeit von DIRSH lautet: A contribution to the fauna of *Acrididae* of Syria and neighbouring countries (*Eos*, XXVI, 1950, p. 62).

Die Grössenangaben des vorliegenden Weibchen lauten: Körperlänge 17.5 mm., Pronotum 3 mm., Elytren 11.5 mm., Hinterschenkel 9 mm.

Das Genus enthält 6 Arten und ist von Algerien bis Zentral-Asien verbreitet, aber aus Ägypten noch nicht angegeben worden.

Cyclopternacris etbaica Rme. (det. DIRSH)

RAMME, Eos, IV, 1928, p. 115, t. 2, f. 3 und 4, Männchen und Weibchen.

Kosseir am Roten Meer, 8. ii. 1956, Entomology Dept., Faculty of Science, Ein Shams University, 1 Weibchen

Grundfärbung hellbraun, Prozona des Pronotums etwas dunkler. Elytren die Hinterknie etwas überragend. Hinterflügel ganz farblos. Vordere Querbinde der Hinterschenkel viel schwächer als die hintere. Hintertibien wie bei RAMME angegeben, nur ist der zweite dunkle Ring sehr schwach ausgebildet.

Körperlänge 41.5 mm., Pronotum 8.5 mm., Elytren 32 mm., Hinterschenkel 23 mm.

Von dieser Art sind bisher überhaupt nur 1 Männchen und 2 Weibchen aus Ägypten bekannt geworden (Etbaiwüste und Northern Etbai).

Das Genus *Cyclopternacris* enthält noch folgende Arten :

C. morbosa (Serv.) 1839, Männchen und Weibchen, Genus-Type. — Ägypten, Sinai, Arabien.

C. hoggarensis Chop., 1929, Männchen und Weibchen. — Hoggar.

C. hemiptera Uvar., 1935, Männchen und Weibchen. — Arabien.

C. omanica Uvar., 1936, Weibchen. — Arabien.

C. sp., Dirsh, 1950, Weibchen. — Transjordanien.

LE GENRE *HYPERASPIS* EN EGYPTE

[*Coleoptera : Coccinellidae*]

par A. ALFIERI

Il résulte de la bibliographie des travaux relatifs aux *Hyperaspis* et *Oxynychus*, que les espèces égyptiennes appartenant à ces deux genres seraient les suivantes:

Hyperaspis marmottani (Fairm., 1868) = *albidiceps* (Walker, 1871), *Hyparaspis polita* Weise (1885), *Hyperaspis pumila* Muls. (1850), *Hyperaspis vinciguerrae* Capra (1929, a et b), *Oxynychus albidiceps* Walker (1871), *Oxynychus erythrocephalus* F. (1787), et *Oxynychus marmottani* Fairm. (1868).

En réalité, l'*Hyperaspis marmottani* (Fairm.) est le seul représentant authentique d'Egypte de la tribu des Hyperaspini de la sous-famille des Coccinellinae.

Nonobstant les travaux de CAPRA (1929, a et b) qui assignent définitivement le *marmottani* (Fairm.) au genre *Hyperaspis*, WINKLER (1924-1932) et KORSCHEFSKY (1931-1932) l'ont maintenu dans le genre *Oxynychus*, auquel il n'appartient sûrement pas.

Il est utile de mentionner ici que le genre *Hyperaspis* se distingue du genre *Oxynychus* par les ongles des tarses qui ne sont pas simplement dilatés à la base, mais aussi nettement dentés lorsqu'ils sont examinés à un fort grossissement.

Les *Hyperaspis polita* Weise et *pumila* Muls. ont été indûment cités d'Egypte, sans doute à cause de leur faciès très semblable à celui du *marmottani* (Fairm.). Il est également fort possible que l'*Hyperaspis pumila* Muls., espèce énigmatique ou très peu connue, soit identique au *marmottani* (Fairm.), et, dans l'affirmative, devrait avoir priorité sur ce dernier.

Le Professeur M. HAFEZ conjointement avec Mademoiselle Samira EL-ZIADY (1952, a, b et c) ont publié trois études remarquables, respectivement sur la biologie, la morphologie, et l'histologie du canal alimentaire de l'*Hyperaspis vinciguerrae* Capra, espèce décrite de la Cyrénaïque. On comprendra aisément que ces études ne peuvent se rapporter qu'au *marmottani* (Fairm.), et non pas au *vinciguerrae* Capra qui n'est pas connu d'Egypte.

Entre autres caractères morphologiques et taxonomiques, le dessin des élytres permet de distinguer à première vue l'*Hyperaspis marmottani* (Fairm.) du *vinciguerrae* Capra.

Chez le *marmottani* la tâche 1 transversale est rétrécie vers l'extérieur, mais amplement réunie à la base à la bande latérale. La bande latérale, qui atteint approximativement les deux-tiers de l'élytre, est rétrécie en arrière sur la moitié antérieure, est fortement dilatée sur la partie postérieure, cette dilatation large de deux à deux et demie fois la largeur du retrécissement médian, à bord supérieur tout au plus anguleux mais parfois presque arrondi. La tâche discale 2 est en ovale court, un peu plus longue que large.

Chez le *vinciguerrae* la coloration des élytres est d'un jaune pâle, avec une étroite bande suturale brune attenuée antérieurement et postérieurement, chacune avec une grande tâche longitudinale brun foncé sur le disque, longue à peu près aux deux tiers de la longueur de l'élytre, moins dilatée postérieurement et tronquée, avec l'angle extérieur sub-droit, à l'intérieur prolongée pour se réunir à la bande suturale bien que parfois cette union est presque oblitérée. Le dessin de l'élytre est évidemment dérivé du dessin typique par la fusion des tâches jaunes. Bordure marginale antérieure et latérale des élytres brune. Epipleures jaune pâle.

Quant à l'*Oxynychus erythrocephalus* F., espèce de l'Europe méridionale et du Caucase, et dont la présence en Egypte est plus que douteuse, il doit être rayé de la nomenclature systématique de la faune coléoptérologique égyptienne.

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ADDITIONS A LA FAUNE COLÉOPTÉROLOGIQUE DE L'EGYPTE ET DU SINAÏ

(avec 1 Figure)

par A. ALFIERI

Mon collègue et ami Monsieur A. DESCARPENTRIES, du Laboratoire d'Entomologie du Muséum National d'Histoire Naturelle de Paris, a bien voulu se charger de la détermination d'un certain nombre de coléoptères innomés de ma collection. A cet effet, il les a soumis aux éminents spécialistes, anglais et français, des Dytiscides (C. LEGROS), Histérides (J. THÉROND), Hydrophylides (J. BALFOUR-BROWNE), Scarabeides (Luc. AUBER), Cérambycides (P. LEPESME), Brenthides et Curculionides (A. ROUDIER). Je remercie bien sincèrement tous ces collabarateurs bénévoles. On trouvera, ci-dessous, la nomenclature des espèces nommées, ainsi que la citation précise des localités de capture, suivie de notes personnelles.

Dytiscidae

Deronectes (Potamonectes) crotchi P. de Borre

Bir Nagat (Wadi Qattar, désert arabique sud-est, approximativement au 27° de latitude), été 1951.

Précédemment connu du Sinaï seulement.

Histeridae

Saprinus (Pholioxenus) rutilus Er.

Ismailia, 11.iv.1933.

BICHKHARDT (Coleopterorum Catalogus, VIII, pars 24, 1910) l'indique dubitativement d'Egypte, et le place dans le sous-genre *Saprinus* s. str.

Saprinus (Hypocaccus) schultzei Schm.

Maadieh (lac Edkou), 20.viii.1934.

Décrit du Maroc. BICKHARDT (*loc. cit.*) le place dans le sous-genre *Pachylopus*.

Hydrophilidae

Limnebius ? fontinalis Balfour-Browne.

Une femelle capturée au Bir Isla (Sinaï, 390m.), le soir à la lampe, 6-9.iv.1940.

Dactylosternum arabicum Balfour-Browne.

Un exemplaire capturé au Bir Isla (Sinaï, 390m.), le soir à la lampe, 6-9.iv. 1940.

Se distingue, à première vue, du *Dactylosternum insulare* Cast., par la taille plus avantageuse et les stries des élytres plus prononcées.

Cercyon dieganus Rég.

Un exemplaire des environs des Pyramides de Ghizeh, en Août 1932.

Précédemment connu de l'Afrique centrale et de Madagascar.

Helochares sharpi Kuw.

Kerdacé, 23.vii.1933.

Déjà signalé d'Egypte par SAHLBERG (*Oef. Finska Vetensk. Soc. Foerh.*, LV (19), p. 48, 1912-13), mais extrêmement rare. KNISCH (Coleopterorum Catalogus, XIV, pars 79, 1924) le place dans le sous-genre *Helocharimorphus*.

Scarabaeidae

Onthophagus inermifrons d'Orb.

Un mâle provenant du Gebel Elba (désert arabique sud-est), 15.iii-fin iv.1928.

Espèce africaine précédemment connue de l'Abyssinie et du Sénégal.

Euparia singularis Har.

Louxor, le soir à la lampe, 30.x.1937 (leg. G. RUNKEWITZ).

Espèce connue de Constantinople, de l'Asie mineure, et que SMITH (Coleopterorum Catalogus, XIX, pars 20, 1910) a placée dans le genre *Coptochirus*.

Cerambycidae

Prionus (Mesoprionus) besicanus Fairm.

Plusieurs mâles et femelles capturés, le soir à la lampe, au Sinaï (El-Arbaein, 10.v.1927; Wadi El-Lega, 3.viii.1943).

Espèce connue de l'Asie mineure, Syrie, Chypre, Turquie et Grèce.

Phoracantha (s. str.) semipunctata F.

A été capturée, pour la première fois en Egypte, au cours de l'été 1945, dans les locaux de l'Ecole allemande du Caire. Retrouvée à Méadi, le soir à la lampe, 12.vi.1946 (mâle) et 9.ix.1953; à Beni-Youssef, sous l'écorce d'un des *Eucalyptus*

bordant la route agricole, 14.i.1948; à Zamalek (Caire), 1950; de nombreux autres individus ont été pris depuis aux environs du Caire. Leur taille varie de 22 à 32 millimètres.

FIG. 1 : *Phoracantha* (s. str.) *semipunctata* F.

Sans aucun doute possible cette espèce du groupe des Cerambycinae-Phoracanthini et décrite de la Nouvelle-Hollande (Australie), a été introduite en Egypte avec des cargaisons de bois importées pour les besoins des troupes australiennes au cours de la guerre mondiale. De toute évidence, elle s'est acclimatée dans notre Pays où ses larves se développent dans le tronc des *Eucalyptus*. Il est à craindre qu'elle ne devienne le fléau de ces arbres et d'autres essences ligneuses, à l'instar du *Xystrocera globosa* Oliv., autrefois également importé d'Australie, et qui ravagea nos *Albizzia lebbek* Benth.

Leptidea brevipennis Muls.

Hawamdieh, 10.v.1940, nombreux individus éclos d'un panier en osier protégeant une dame-jeanne.

Cette espèce, originaire de l'Europe méridionale, est de récente importation en Egypte. Sa biologie a été étudiée par DELARUE (*Feuille Jeunes Natur.*, VI, 1875), par PERRIS (*Ann. Soc. Linn. Lyon*, XXIII, 1877), NICOLAS (*Ann. Acad. Vaucluse*, 1884, et *Le Coléoptériste*, 1891), et par XAMBEU (Mœurs et Métam., VIII, 1902).

Chrysomelidae

Clytra nigrocincta Lac.

Wadi Talaa (Gebel Katherin, Sinaï), 19.iv.1940; Wadi Isla (Karm Alam, 680 m., Sinaï méridional), 10-12.iv.1940.

Espèce citée d'Egypte dans la "List of Egyptian Insects in the collection of the Entomological Section, Ministry of Agriculture (Government Press, 1949)", mais son véritable habitat égyptien est uniquement sinaïtique.

Brenthidae

Amorphocephalus princeps R. Kleine

El-Kontella (nord Sinaï), le soir à la lampe, 25.v.1935, plusieurs mâles et femelles.

Espèce décrite du Soudan.

Curculionidae

Trachyphloeus aureocruciatus Desbr.

Un exemplaire provenant de Borg El-Arab: Abou Sir (Mariout), 18.iii.1935.

La plus petite espèce des Otiorrhynchinae d'Egypte, précédemment connue de presque toute l'Europe méridionale. Sa biologie a fait l'objet de deux études publiées par BARGAGLI (*Boll. Soc. Ent. Ital.*, XVI, 1884, et XVIII, 1886).

Lixus (Phillixus) biskrensis Cap.

Un exemplaire du Mex (Alexandrie), 15.viii.1934.

Espéce décrite de l' Algérie.

Lixus (Compsolixus) ascani wagneri Luc.

Un individu du Wadi El-Ghedeirat (nord Sinaï), 24-25.v.1935.

Décrit de l'Algérie, signalé de Tunisie et du Caucase.

Lixus (Lixochelus) cardui Ol.

Un spécimen du Sinaï (Gebel Katherin: Wadi Talaa), 19.iv.1940.

Espéce connue de l'Europe centrale et méridionale, du Caucase et de la Perse. Sa biologie a été étudiée par FRAUENFELD, en 1863.

Cleonus (Leucomigus) candidatus albotessellatus Fairm.

Un exemplaire du Sinaï (Wadi Tayeba, 23.ix.1941).

L'espèce type est connue de la Russie méridionale, du Caucase, de la Transcaspie et du Turkestan. L'aberration *albotessellatus* Fairm. est décrite de l'Algérie.

Ita crassirostris Tourn.

Plusieurs individus récoltés au Sinaï (Wadi Ghedeirat, 13.iii.1937).

Espèce connue de la Sicile, de l'Espagne et de l'Algérie, et qui appartient à la tribu des Itini de la sous-famille des Erirrhininae.

Barytychius squamosus Gyll.

Ikinghi-Mariout (région maréotique), 6.iv.1937, un seul exemplaire.

Connu du sud de l'Europe, du bassin méditerranéen, du Caucase, de la Syrie et du nord de l'Afrique.

Phytonomus (Tigrinellus) pastinacae Rossi

Un individu récolté à Siouf (environs d'Alexandrie), 11.v.1930.

Connu de l'Europe centrale, Italie, France méridionale, Maroc, Algérie, Perse et Chypre. Sa biologie a été étudiée par BARGAGLI (*Boll. Soc. Ent. Ital.*; XVI, 1884, et XVIII, 1886) et par KLEINE (*Entom. Blätter*, VI, 1910).

Elasmobaris bedeli Faust

Wadi El-Ghedeirat (nord Sinaï), 24-25.v.1935.

Décrit de Biskra (Algérie).

Ceuthorrhynchus (Dionoremus) intersetosus Weise

Mandarah (à l'est d'Alexandrie), un exemplaire, 5.iv.1943.

Habite la France méridionale, l'Espagne, l'Algérie et la Palestine.

PETERIMHOFF (*Ann. Soc. Ent. France*, 1911, p. 307) et HUSTACHE (Rév. *Centhorrhynchus* Gallo-Rhénans, 1924), ont publié la biologie de cette espèce.

Hemiphytobius spec.

Un exemplaire de Montazah (environs d'Alexandrie), 7.iii.1929.

Le genre *Hemiphytobius*, de la sous-famille des Ceuthorrhynchinae, a été établi par WAGNER (*Entom. Blätter*, XXXIII, 1937) pour diverses espèces des genres *Hypurus* et *Pseudophytobius* de la tribu des Hypurini.

Gymnetron variabile Rosenh.

Ikinghi-Mariout, 16.iii.1935, un seul exemplaire.

Espèce connue du bassin méditerranéen occidental, de l'Italie, Grèce, îles Baléares et Algérie.

LIFE-HISTORY AND FEEDING HABITS OF *PAEDERUS ALFIERII* KOCH

[*Coleoptera: Staphylinidae*]

(with 25 Text-Figures and 3 Tables)

by MOSTAFA KAMAL AHMED, PH. D.,

Faculty of Agriculture, Cairo University, Giza.

INTRODUCTION

Paederus alfierii Koch is a common Staphylinid beetle which was known in Egypt as *Paederus fuscipes* Curtis. KOCH (1934) described *P. alfierii* as a new species, and gave the main characteristics which differentiate it from *P. fuscipes*.

P. alfierii adults are found in large numbers actively crawling on Egyptian clover (berseem), cotton and corn plants. They are considered an important predator of the cotton leaf-worm, *Prodenia litura* F.. BISHARA (1934) and KAMAL (1951) reported that the number of these beetles might exceed 50.000 individuals per acre during the months of June and July.

This insect is known only in the adult stage and none of the immature stages are ever seen. Apparently, the only published information on its life-history was given by KAMAL (1951), who gave only a very brief description of the egg and the first instar larva.

The purpose of this work is to study the life-history of this widely distributed insect in Egypt, and to obtain a comprehensive information on the feeding habits of the larvae and the adults.

MATERIAL AND METHOD

Adult beetles were collected from the field. They were reared under glass chimneys (12 cm. high and 9.5 cm. in diameter) placed over porcelain dishes (3 cm. high and 14 cm. in diameter) filled with a layer of wet sand. Damp soil and decaying

plant leaves, previously infested with springtails, were enclosed inside each chimney for a depth of about two inches. A piece of absorbent cotton saturated with water was fixed to the wall of the chimney. Leaves heavily infested with aphids or with young larvae of the cotton leaf-worm were offered daily to the beetles. The sand and the soil were moistened with water every other day to keep them damp. This culture served as a source for all the immature forms required for further study.

The same technique, without soil in the chimneys, was used in the feeding studies of the adults. The petiole of a cotton leaf, infested with a known number of the host individuals, was submerged in water in a small glass dish 3 cm. high and 4 cm. in diameter. The dish was then covered with a piece of absorbent cotton and the chimney was placed over it. When eggs of *Prodenia* and *Earias* were used, they were singly fixed on the upper surface of the leaf-blade by means of water.

In some experiments, the beetle was forced to feed on one kind of food or on a specific instar larva of *Prodenia* (Table I). In other experiments, the adult beetle was offered a mixture of different larval instars of *Prodenia* (Table II), or of other kinds of food (Table III).

The duration of the immature stages as well as the food habits of the larvae were studied by keeping each larva separately in a small specimen tube (5 cm. high and one cm. in diameter) containing little damp soil which was always kept wet. Food was added daily.

LIFE - HISTORY

The egg

Eggs are generally laid singly in soft decaying plant matter or in damp soil. However, they are found sometimes close together in couples. They are very sensitive

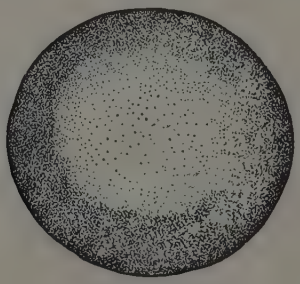

FIG. 1 : The egg.

to dryness and will shrink quickly if humidity becomes low in the medium. The egg is almost spherical in shape (Fig. 1), and averages 0.62 mm. in diameter.

This does not agree with the description given by KAMAL (1951), in which he stated that the egg measures about 3 mm. long and 1 mm. in diameter. It is pale to dark creamy-orange in colour. Its surface is sculptured with microscopic depressions which, under high magnification, give it a granular appearance.

The incubation period is about three days in summer at 30 °C. and 70% relative humidity, and about 16 days during the winter months.

Number of larval instars

MANK (1923) found only two instars in *Philonthus cyannipennis* Fab.. She thought, however, that it might have molted once before its capture since XAMBEU had recorded that the staphylinid larvae molt three times at least.

Only two larval instars have been found in *Paederus alfierii* Koch.

The first instar larva

The newly hatched larva (Fig. 2) is of the campodeiform type, widest at the thoracic segments and gradually tapering posteriorly. The head is prognathous,

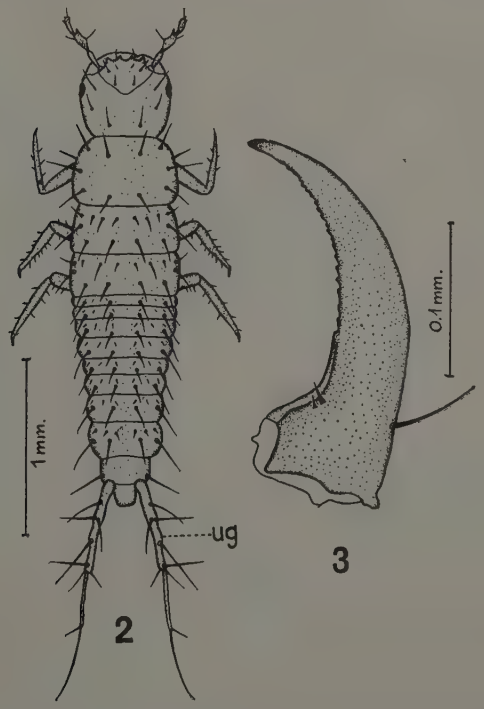

FIG. 2 : First instar larva (ug, urogomphus). — FIG. 3 : Right mandible of first instar larva.

heavily sclerotized and averages 0.62 mm. long and 0.53 mm. wide, between the eyes. The mandible (Fig. 3) is strong, claw-like, 0.29 mm. long and 0.11 mm. at its widest part. The three thoracic segments are almost as long as the abdomen and bear three pairs of strong legs.

Dorsally, the mesothorax, metathorax, and each of the first eight abdominal segments bear two rows of spines: an anterior row of six short spines and a posterior row of four very long ones. The ninth abdominal segment bears dorsally a pair of two-segmented urogomphi (Fig. 2, ur) each ending with a long bristle. The urogomphi are carried obliquely above the body level. The tenth abdominal segment is very small and ends with the anus. The larva has the ability to bend the end of its abdomen upwards like a scorpion, particularly when feeling in danger.

The newly hatched larva is dirty white in colour but, after several hours, turns to dirty brown. It averages 3.2 mm. long (including urogomphus) and 0.63mm. wide at the prothorax. When fullgrown, it measures about. 4.5 mm. longand 0.67 mm. wide at the prothorax. The larva is very active and always hides in the soil. This instar lasts 5 days in summer at 30°C. and 70% relative humidity, and 11 days in winter.

The second instar larva

At the beginning, the second instar larva is brown in colour. As it grows older, an orange colour appears posteriorly and extends anteriorly from one segment to the other. When fullgrown, the head, the tergal and pleural plates become light testaceous-brown, while the rest of the body assumes a bright orange colour, with the exception of the sternal plates which are light-brown to yellowish-brown. The ninth and tenth abdominal segments, and a basal piece of urogomphi are brown.

When young, this instar is widest at the prothorax, somewhat depressed and gradually tapering toward the end; however, when fullgrown (Fig. 4), it is broadest about the middle of the abdomen and averages 6.7 mm. long (including urogomphus) and 1.3 mm. at the widest part. The duration of this instar averages 8 days in summer at 30°C and 70% relative humidity, and about 18 days in winter.

The head (Fig. 5) is almost quadrate, slightly narrower than the thorax, and measures about 0.85 mm. long and 0.71 mm. at its widest part. It is heavily sclerotized and constricted at the posterior end forming a neck-like structure which is one-half as wide as the head. The ecdysial cleavage line is very prominent on the dorsal surface of the head. It starts just behind the antennae. Its coronal stem is about two-thirds longer than each frontal arm. The ventral surface of the head has an elongated gula (Fig. 6, gu) which is continuous with the postmentum of the labium. Six black ocelli, arranged in two groups of three each, are found on each side of the head (Fig. 7). MANK (1923) reported that XAMBEU had also found six ocelli in two rows in *Paederus tempestivus*.

The antenna arises dorsally at the base of the mandible, and is four-segmented (Fig. 8). The first segment is short, with its base wider than the apex; second

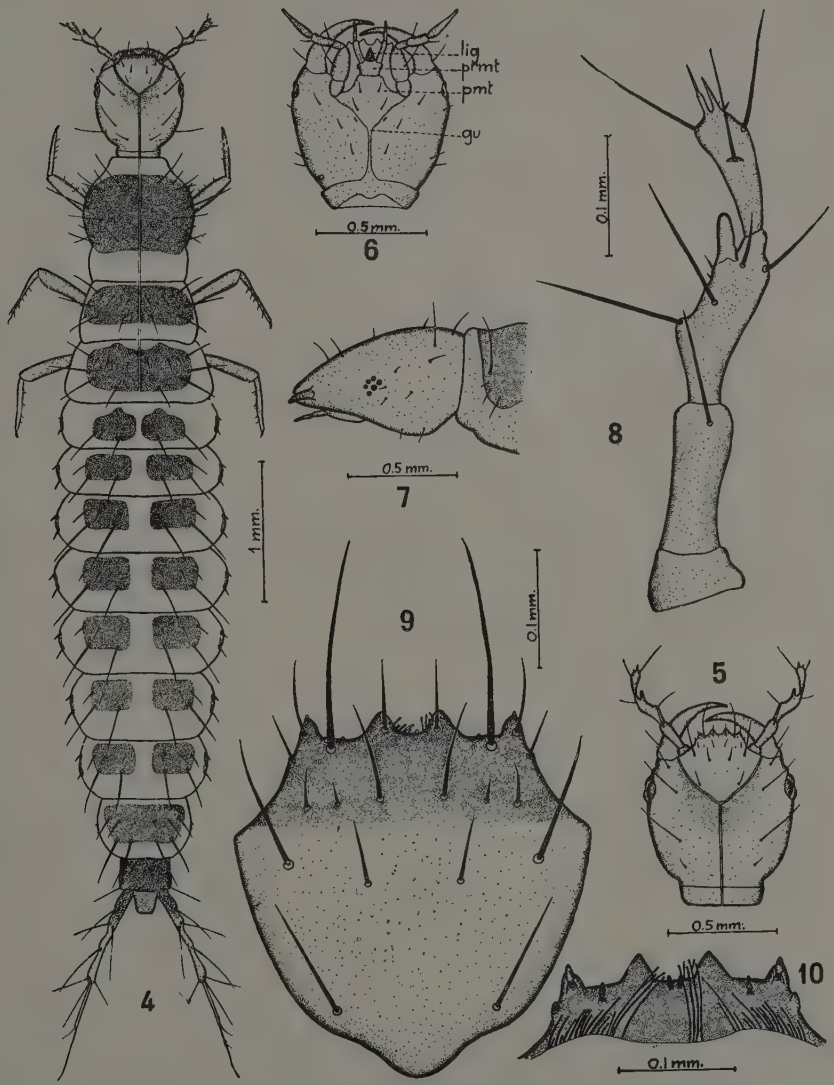

FIG. 4 : Fullgrown second instar larva. — FIG. 5 : Dorsal aspect of head of fullgrown larva. — FIG. 6 : Ventral aspect of head of fullgrown larva (ug, gula; lig, ligula; pmt, postmentum; prmt, prementum). — FIG. 7 : Lateral aspect of head of fullgrown larva showing ocelli. — FIG. 8: Right antenna of fullgrown larva. — FIG. 9 : Dorsal aspect of upper lip. — FIG. 10 : Ventral aspect of anterior margin of upper lip.

segment cylindrical, about three times as long as the first, and provided with one long hair-like seta; third segment little longer than the second, bearing on the inner side an immovable finger-like lobe (the thumb of VORIS, 1939) which exceeds the tip of the third segment. There are four hair-like setae on this latter segment: a long one on the inner margin at the broadest part of the segment, another long one situated more dorsally, and two shorter setae at the same level with the base of the thumb. The fourth segment is little shorter than the second and gradually broadens towards the apex, where it ends into two dorsal spine-like projections. The basal half of the inner projection is much wider than the apical half which tapers suddenly.

Mouth parts : There is no agreement on a name for the part of the head surrounded by the frontal arms of the ecdysial cleavage line, because of the disagreement on the homology of this region. VORIS (1939) named its anterior edge the "clypeo-labral margin" and its posterior bounding the frontal suture. PETERSON (1951) believed that this region is a combined frons, clypeus and labrum. Both authors used no name for this part. The term "upper lip", suggested by WADSWORTH (1915) and adopted by MANK (1923), will be used here.

The upper lip (Fig. 9) is shield-shaped with a four-toothed anterior margin. It carries four transverse rows of setae which are different in length and are arranged in the following manner : the anterior row consisting of six short setae and two very long and hair-like ones situated on the toothed margin; each of the next three rows has six, four and two setae, respectively (Fig. 9). Ventrally, the anterior margin ofthe upper lip bears eight small pegs arranged as shown in Figure 10. All of them project very little from the margin and so do not appear dorsally, except under high magnification. Thread-like sensilla are also located ventrally on the anterior third of the upper lip. It is about 0.37 mm. long and 0.29 mm. at its widest part.

The mandible is rather sickle-shaped with a finely toothed inner margin. It has two spines on the inner edge and one flexible seta near the base of the outer margin (Fig. 11). It averages 0.39 mm. long and 0.13 mm. at its widest part.

The maxilla (Fig. 12) has two segmented cardo. The first segment is very small and more sclerotized than the second, which is as long as broad and large in size. The stipes is more or less slender in shape and about twice as long as broad. It bears dorsally two long setae and a number of sensory spines. Its tip is provided with an immovable lobe, the mala, on the inner margin (Fig. 12, ma). This mala has four fied spines at its tip : two short ones situated dorsally, and two longer ones located ventrally. The maxillary palpus (Fig. 12, mxp) is three segmented. Only the middle segment bears one long seta at each end. The first and second segments are slender, but the terminal segment is narrower and tapers apically where it carries certain sensory organs appearing as light and narrow stripes alternated with dark ones (Figs. 12 and 13).

The body of the labium consists of three parts, an anterior plate or ligula, a prementum, and a posterior part or postmentum. The ligula (Fig. 14, lig) is conical

in shape and densily covered with fine spines. The prementum (Fig. 14, prmt) is movable, almost as long as broad, and bears two setae. The postmentum (Fig. 6, pmt) is a broad plate in the ventral wall of the head. The labial palpusis two-segmented and the terminal segment has the same sensory organs found on the maxillary palpi.

Thorax : The prothorax is well developed and is as long as both the mesothorax and metathorax combined. The prothorax is light brown in colour and have a heavily sclerotized tergal plate. Its lateral margins are round and carry many setae.

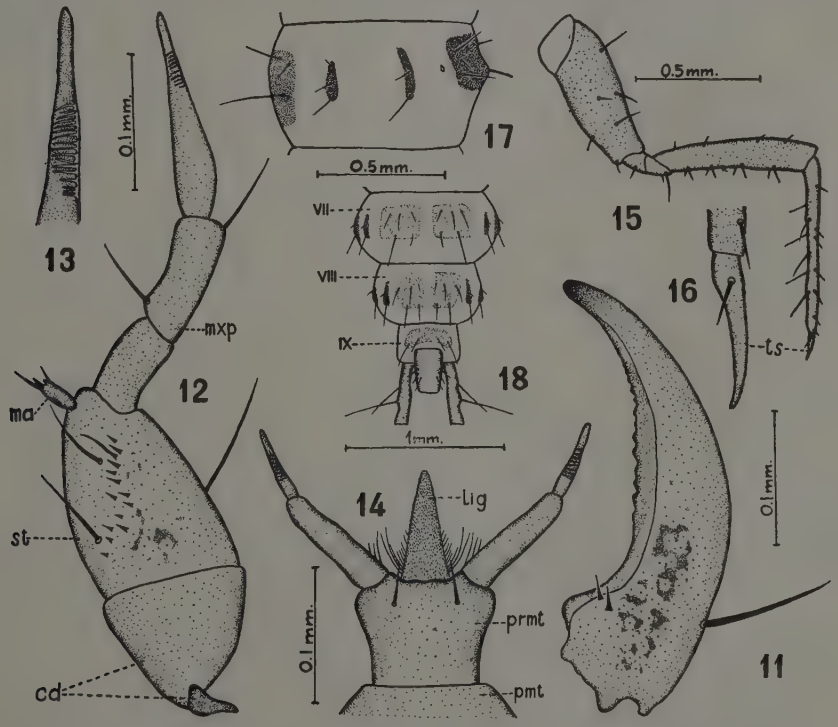

FIG. 11 : Right mandible of second instar larva. — FIG. 12 : Dorsal aspect of right maxilla (cd, cardo; st, stipes; ma, mala; mxp, maxillary palpus). — FIG. 13 : Tip of maxillary palpus showing sensory organs. — FIG. 14 : Ventral aspect of labium (lig, ligula; pmt, postmentum; prmt, prementum). — FIG. 15 : Right hind leg of fullgrown larva (ts, tarsungulus). — FIG. 16 : End of hind leg : (ts, tarsungulus). — FIG. 17 : Lateral aspect of 5th abdominal segment of fullgrown larva showing pleural plates. — FIG. 18 : Ventral aspect of posterior end of fullgrown larva (VII, VIII and IX, 7th, 8th, and 9th abdominal segments.

The mesothorax and metathorax are nearly equal in length. Each of the mesonotum and metanotum is provided with some setae arranged into two transverse rows,

beside two long ones on each side. The coronal stem of the ecdysial cleavage line extends posteriorly from the head over the dorsum of the thorax. It appears as a light line dividing the thoracic terga into equal halves (Fig. 4).

Legs : Each leg (Fig. 15) consists of a long coxa, a small two-segmented trochanter, a slender femur which is as long as the coxa, a narrower tibia covered with many small setae, and a pointed and fixed tarsungulus (Fig. 16, ts) which carries a movable claw-like seta on each side.

Abdomen : A pair of sclerotized tergal plates occupy most the dorsum of each of the first seven abdominal segments. Those of the first abdominal segment are smaller and have a special shape (Fig. 4), but the other six pairs are more or less quadrate. Each plate bears two long setae on its posterior margin and three shorter ones forming a row across the middle part of the plate. The eighth abdominal tergum forms one continuous plate which bears the same number of setae on each previous pair (Fig. 4). The ninth abdominal tergum is dark brown, heavily sclerotized, and carries only one long seta on each side. The tenth abdominal segment is very narrow and also dark brown in colour. The ninth segment possesses a pair of movable, two-segmented urogomphi. The first segment of each urogomphus is twice as long as the second segment and bears seven very long hair-like setae. The second segment is very narrow and slender, and carries one short seta on the ventral side of its distal end where it terminates with a long bristle.

The first abdominal segment possesses one pleural plate on each side. A pair of pleural plates, however, is present on each side of the second to the eighth abdominal segments (Fig. 17). The dorso-lateral plate is elongate and banana-shaped, while the ventro-lateral one is shorter and pear-like. Each plate carries three short setae : a very short one on the anterior tip, a longer one on the midde, and the longest seta on the posterior end of the plate (Fig. 17). Only the dorso-lateral pleural plate of the first abdominal segment is present and bears one seta on the middle. Both the 9th and 10th abdominal segments are void of any pleural plates.

Ventrally, a pair of sternal plates is found on the first eight abdominal segments (Fig. 18). They are pale brown in colour and very lightly sclerotized. Each plate bears the same number of setae and have the same arrangement as those of the tergal plate. The ninth abdominal segment has only one sternal plate which bears four setae only (Fig. 18, IX).

The prepupa

The prepupa is found at a depth of one to two inches, protected inside a small cell in the moistened soil. It is always lying on its side with the head carried in a vertical position on the thorax (Fig. 19). Although it has exactly the same general features of the fullgrown larva, yet the six black ocelli have a different position. They are situated latero-ventrally near the posterior end of the head, and are arranged in a special pattern (Fig. 20). Small colourless elevations are still found behind each mandible in the normal place of the ocelli of the second instar larva, indicating that

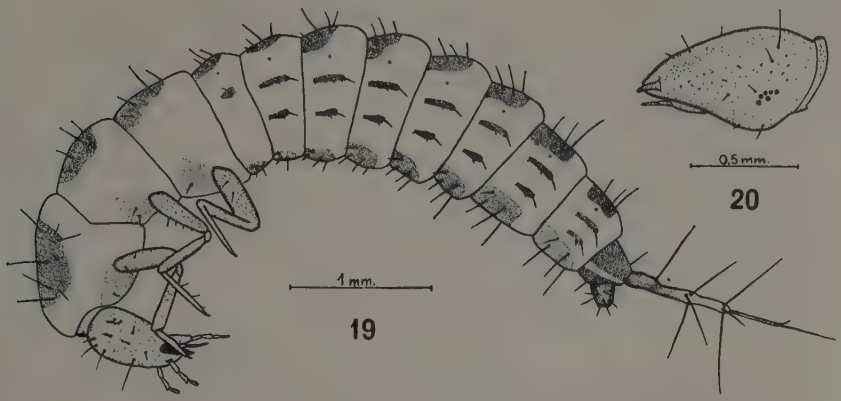

FIG. 19 : Prepupa. — FIG. 20 : Lateral aspect of head of prepupa showing ocelli.

the change has happened only in the tissues of the head of the prepupa during preparing itself for pupation.

This stage takes 24 hours at 30°C. and 70% relative humidity, while it lasts about 5 days during the winter months.

The pupa

The pupa is of the exarate type and measures about 4.5 mm. long and 1.3 mm. at the widest part of the abdomen. It is covered with a thin, colourless and semi-transparent membrane. MANK (1923) studied the biology of six species of Staphylinidae and found that only the pupa of *Tachinus flavipennis* Dej. has this soft coating. She stated that "the pupa is different from any of the other Staphylinidae under consideration. Instead of being thoroughly chitinized, it is covered with a soft substance which is pure white at first".

The head (Fig. 22, hd) is completely concealed under the large prothorax and therefore cannot be seen from the dorsal surface (Fig. 21) The prothorax (Fig. 21, th1) is almost round in shape with a more or less straight posterior edge. It carries a number of hair-like setae beside two pairs of long barbed hairs on its dorsal surface. While one pair is on the anterior margin, the other pair is near the posterior end (Figs. 21 and 22). Each barbed hair has a sclerotized ring near its base (Fig. 23, B). The barbs are much less on the basal part.

The mesothorax is small and bears the fore wings which extend over the sides of the metathorax. This latter segment is as long as the prothorax and bears the hind wings which extend laterally untill the first abdominal segment, then latero-ventrally where they end about the middle of the abdomen. Ventrally, the distal half of each hind wing covers the corresponding hind leg till the first tarsal segment. A part of the femur and tibia of each leg lies on each side of the body.

The mesothorax, metathorax, and first abdominal segment do not bear any kind of hairs or setae. A long barbed hair is carried on each side of the second to the eighth abdominal segments. Each hair (Fig. 23, A) differs from that found on the prothorax in carrying a ventral seta at the base. The barbed hairs of the second and third abdominal segments are curved upward, while those of the 4th, 5th, and 6th abdominal segments are directed posteriorly over the sides of their segments. The hairs of the 7th and 8th abdominal segments are curved downards. A row of four pairs of small setae is found on the posterior margin of the second to the eighth abdominal segments. The last abdominal segment is small and ends in two projections terminating in a point. Each projection carries a group of fine hairs.

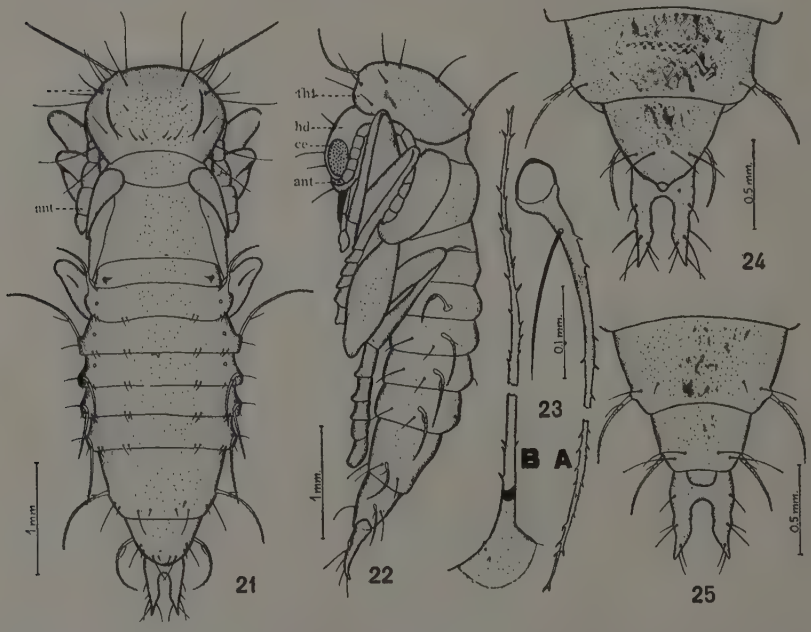

FIG. 21 : Dorsal aspect of pupa (ant, antenna; th1, prothorax). — FIG. 22 : Lateral aspect of pupa (ant, antenna; ce, compound eye; hd, head; th1, prothorax). — FIG. 23 : (A) Ventral aspect of barbed hair from 4th abdominal segment of pupa; (B) Barbed hair from 1st thoracic segment of pupa. — FIG. 24 : Ventral aspect of posterior segments of female pupa. — FIG. 25 : Ventral aspect of posterior segments of male pupa.

Four pairs of visible spiracles are found on the dorsal sides of the first four abdominal segments. The first pair is large, conical in shape and heavily sclerotized; while the other three pairs are small and round.

The newly formed pupa is yellowish-cream in colour except the last three abdominal segments which are semi-transparent. Dark brown spots appear gradually in the compound eyes (Fig. 22, ce), untill all the eyes become dark brown. The pupa turns to dark orange in colour as it gets older. One day before emergence, the head, antennae and small pieces of the femora and tibiae around their joints turn brown. Also most of the seventh, eighth and ninth abdominal segments become black in colour.

The two sexes can be differentiated in the pupal stage by the ventral surface of the posterior end. In the female, the ninth abdominal segment is conical in shape and has a pointed tip (Fig. 24). In the male, this segment is blunt and has a parallel anterior and posterior margins; its posterior edge carries a small lobe which develops into some parts of the male genitalia (Fig. 25).

Usually, the pupa rests on its back although sometimes it is found on its side. It has never been seen resting on the ventral side. It becomes highly disturbed when exposed to light and tries to move away from it, moving in circles with the head as its centre.

The pupal stage lasts 3.5 days on the average at 30°C. and 70% relative humidity, and 15 days during the winter months.

The adult

Emergence of adults always occurs at night. The adult emerges through a mid-dorsal slit on the thorax of the pupa leaving the membraneous pupal skin (exuvia) in the soil. The elytra of the newly hatched adult are shining creamy white in colour. Winthin the first day they turns to dark cream, then to brown, and finally becomes bright dark bluish in colour. The hind wings stay for several hours extending on both sides of the body to its posterior end before they are folded under the short elytra.

The adult remains in the soil for one day after emergence, then starts its activities on the plants. At this age, it averages 5.5 mm. long, but after about three on four days later, it attains about 7.5 mm. long. This increase in length is due to the expansion of the telescoped abdominal segments after feeding.

The sex-ratio is represented by four females to one male. This may explain the rapid increase of the insect population during summer months. Fed adults, kept under outdoor conditions, lived about 4 months in summer, and 6 months when emergence occurred in winter (December). Unfed adults died after about two days from emergence.

FEEDING HABITS

Records on the feeding of larvae of *Paederus alfierii* Koch show that they live only on springtails (Collembola). They failed to feed on very small species of

earthworm, soil mites, red spider mites, aphids, and cotton leaf-worm eggs and larvae.

The larva wanders about in the soil. When it comes close to a sprintail, it suddenly attacks it, holding it between the mandibles, thus sucking out the body juices which can be discerned through the semi-transparent head of the larva. While feeding, the larva manipulates the host by the prothoracic legs to change its position between the mandibles. As soon as all the juices have been extracted the body is discarded. This act takes but 2-3 minutes, after which the larva cleans its mouth-parts by the aid of its fore legs.

The adult beetle has a completely different feeding habits. WILLCOCKS and BAHGAT (1937) stated that it ate the eggs and very young larvae of *Prodenia litura* F. The present work showed that adults can live on the following kinds of food: honey, the cotton aphid (*Aphis gossypii* Glover), the duranta aphid (*Aphis durantae* Theobald), eggs and larvae of the cotton leaf-worm (*Prodenia litura* F.), eggs of the spiny bollworm (*Earias insulana* (Boisd.)), and eggs of the black cutworm (*Agrotis ypsilon* (Rott.).

The adult beetle consumed daily an average of 28.6 *Prodenia* eggs, while it consumed only 17.7 *Earias* eggs in the same period (Table I). This might be due to the larger size of the latter, since the *Prodenia* egg averages only 0.51 mm. in diameter while the *Earias* egg is about 0.60 mm. in diameter. BISHARA (1934) stated that a single adult ate 22 *Prodenia* eggs daily. WIESMANN (1952) reported that 15 *Paederus* adults consumed 0 to 4 egg-masses of *Prodenia* within 4 days.

TABLE I

Average daily consumption of different cotton pests when offered separately to one Paederus *adult*

Host		Average dimensions of host	Average number consumed daily
Earias eggs		0.60 mm. diam.	17.7
Prodenia eggs		0.51 mm. diam.	28.6
Larvae of *Prodenia litura* F.	First instar (young)	1.8 × 0.3 mm.	24.2
	First instar (fullgrown)	2.8 × 0.4 mm.	18.7
	Second instar (fullgrown)	4.0 × 0.6 mm.	7.4
	Third instar (young)	5.0 × 0.6 mm.	3.0
	Third instar (fullgrown)	8.0 × 0.1 mm.	0.9
	Fourth instar (young)	9.0 × 1.3 mm.	0.4
	Fourth instar (fullgrown)	12.0 × 1.5 mm.	0.3
	Fifth instar (fullgrown)	18.0 × 2.5 mm.	0.1
	Sixth instar	25.0 × 3.0 mm.	—
Cotton aphid		0.78 × 0.42 mm.	11.6
Red spider mite		0.44 × 0.23 mm.	—

Paederus adults also feed on the first to fifth instars of *Prodenia* larvae, leaving the sixth one. Each adult consumed an average of 24.2 newly hatched larvae, which was fairly close to the number of eggs eaten (Table I).). This number dropped as the host grew older until it reached an average of 0.1 for the fifth instar larva of *Prodenia*. The beetles usually do not feed on this latter instar larva unless forced. They refused it on the first day but started feeding on the second or third day being the only available food. BISHARA (1934) reported that one beetle consumed daily 15, 8, 6.5, 2.5, 0.7, or 0.5 of newly hatched, one day, two days, three days, four days and five days old *Prodenia* larvae, respectively. They also refused to feed on red spider mites; however, a single beetle consumed an average of 11.6 cotton and aphids (Table I).

TABLE II

Preference and average daily consumption of Prodenia *larvae of different instars when offered simultaneously to one* Paederus *adult.*

Host	Average dimensions of host in mm.	Average number consumed daily
First instar	2.1 × 0.4	9.6
Second instar	3.9 × 0.7	2.7
Third instar	8.0 × 1.3	0.2
Fourth instar	11.0 × 1.6	—
Fifth instar	16.0 × 2.0	—

When the mixture of *Prodenia* larvae of different instars was offered simultaneously, the *Paederus* beetle preferred the first instar larvae, since it consumed an average of 9.6 larvae of this stage (Table II). Besides, it ate an average of 2.7 and 0.2 second and third instar larvae, respectively (Table II). None of the 4th and 5th instar larvae were ever fed on in this case. WIESMANN (1952) also stated that *Paederus* adult feeds on *Prodenia* larvae up to the third instar.

When the beetles were given the choice between cotton aphids, *Prodenia* eggs, *Earias* eggs, and first instar larvae of *Prodenia*, they preferred the eggs and larvae of *Prodenia* rather than the *Earias* eggs and the cotton aphids (Table III).

The beetle is a poor feeder on aphids when other hosts are present. Only an average of 1.2 aphids were consumed as compared to an average of 19 and 11 eggs and first instar larvae of *Prodenia*, respectively (Table III).

When feeding, the adult picks up the egg or the small larva off the surface of the leaf and crushes it between the mandibles. Sometimes, when the egg is tightly fixed on a leaf, the insect first struggles until it picks up the host between the mandibles, then starts feeding. In the case of *Prodenia* eggs, which are deposited in masses, the adult picks up and feeds on one egg at a time.

When feeding on aphids or eggs, the beetle consumes the whole host without leaving any remains. On the other hand, it eats only the body of the first and second instar larvae of *Prodenia* and discards the crushed head capsule. In case of the advanced third instar larva, the beetle eats the body wall and all the body muscles of the host leaving the alimentary canal (as if it is dissected out) and the unharmed head

TABLE III

Preference and average daily consumption of cotton aphids, Earias *eggs, eggs and first instar larvae of* Prodenia *when offered simultaneously to one beetle.*

Host	Average number consumed daily
Cotton aphids	1.2
Prodenia eggs	19.0
Earias eggs	5.3
First instar larvae of *Prodenia*	11.0

capsule. Sometimes, they leave also the thoracic legs attached to the alimentary canal. In the case of older instars, the beetle leaves also the skin and eats only the body muscles.

Frequently, the grown larvae and adults of *Paederus alfierii* are found attacking their own first instar larvae. In one case a *Paederus* adult, in the presence of *Prodenia* eggs and cotton aphids, was seen attacking a pupa of *Leucopis puncticornis* F. (Diptera: Ochthiphilidae). The beetle held the pupa by the prothoracic legs and ate all the contents leaving only the pupal skin. This process lasted 15 minutes. In another instance, an adult attacked a small nymph of *Orius* spec. (Hemiptera : Anthocoridae).

SUMMARY

Paederus alfierii Koch has been reared in damp soil and decaying plant leaves infested with springtails. Rearing took place under glass chimneys, and the adults were supplied daily with aphids or young *Prodenia* larvae.

The egg is creamy-orange in colour, spherical in shape, averages 0.62 mm. in diameter, and is usually laid singly in the soil. The incubation period averages about three days in summer, and about 16 days in winter. Only two larval instars occur. The first larval instar lasted 5 days in summer and 11 days in winter, while the second larval instar lasted 8 and 18 days in summer and winter, respectively. The newly hatched larva is dirty brown in colour. The full-grown second instar larva is orange coloured, except the head, tergal plates and pleural plates which are light

testaceous-brown. The larva is of the campodeiform type, and gradually tapers posteriorly. Dorsally, the ninth abdominal segment bears a pair of movable, two-segmented urogomphi. The external morphology of the fullgrown larva is studied in detail. The pupa is very characteristic, and both sexes can be differentiated at this stage through the ventral surface of the posterior end. The newly emerged adult has a shining creamy-white elytra which darkens gradually. This adult is 5.5. mm. long, and attains 7.5 mm. in length after feeding. It lives about 4 months in summer and about 6 months when emergence occurred in winter (December).

Both larvae and adults were offered different kinds of food to study their feeding habits. The larva fed only on springtails, while the adult preferred eggs and first instar larvae of *Prodenia litura* F. They also ate eggs of *Earias insulana* (Boisd.) and *Agrotis ypsilon* (Rott.), cotton aphids, duranta aphids, and *Prodenia* larvae up to the fifth instar only. They refused red spider mites.

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ON THE MOUTH PARTS OF THE LARVAL INSTARS OF *AEDES AEGYPTI* (L.)

[*Diptera* : *Culicidae*]

(with 38 Text-Figures)

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CONTENTS

I. Introduction. — II. Rearing, feeding habits, and technique. — III. General morphology of the head. — IV. Mouth parts of the fourth instar larva. — V. Mouth parts of the third instar larva. — VI. Mouth parts of the second instar larva. — VII. Mouth parts of the first instar larva. — VIII. Summary of the important instar differences. — IX. Key to the larval instars of *Aedes aegypti* based on the head structures. — X. Acknowledgments. — XI. Bibliography.

I. INTRODUCTION

In this study the morphology of the larval head of *Aedes aegypti* (L.) in general and the mouth parts in particular have been studied through the different instars. It was planned this would enable the writer to construct a key, based on the most significant instar differences. The homologies of the parts of the mouth with those of the generalized insects have been discussed. The writer used the same nomenclature he used in his previous work on *Anopheles quadrimaculatus* (Say). (SHALABY, 1956). In addition to the outstanding works of MEINERT (1886), RASCHKE (1887), and NUTTALL and SHIPLEY (1901), some of the leading papers are those of SALEM (1931), COOK (1944a), and FARNSWORTH (1947). SALEM (1931), worked on *Aedes aegypti*. Although his illustrations are not detailed enough to be of taxonomic use, yet he gave a detailed description of the mouth parts.

II. REARING, FEEDING HABITS, AND TECHNIQUE

The larvae of *Aedes aegypti* (L.) are easy to rear in the laboratory. Eggs are dropped in a tray full of pond water, with some fresh material from the bottom of the pond, which provides all the necessary larval food. The larvae grow and moult with practically no mortality. They have the grazing feeding habit in all the instars, and they graze for their food with the help of the pectinate hairs of their labral brushes from the surfaces of submerged leaves. They are found in nature, breeding in grass-bottomed and grass-sided streams, and have been also found in natural pools and in natural water holes in the ground. BERNER (1947) states that they are even found in water in the axils of banana trees in South Africa.

The larvae are killed in hot water before preservation in 70% alcohol to clear properly. For the detailed study, they are transferred to 95% alcohol and then to a stender dish containing pure beechwood creosote for clearing. When clearing has been completed, the specimens are tranferred to xylene for not more than one minute, and then removed to a clean slide preparatory to permanent mounting in a xylene-soluble medium like Canada balsam. After being covered with a cover slip, the slide is to be placed for a short while in an oven at 40°C., after which the specimens are ready for study.

III. GENERAL MORPHOLOGY OF THE HEAD

The head of *Aedes aegypti* is prognathus in all the instars. It is somewhat oval in shape. The frons covers almost the entire dorsum. The fronto-postclypeal suture is obsolete which resulted in the fusion of the postclypeus and the frons forming the fronto-postclypeus (Fig. 1, FPc). The frons is bounded laterally by the frontal sutures which meet each other meso-caudad forming a relatively short coronal suture which extends caudad to the margin of the occipital foramen (OcFr). The fronto-postclypeus is bounded cephalad by the clypeal suture (Fig. 2, CS) which separates it from the preclypeus (Prc). The lateral extremities of the preclypeus extend caudad on each side of the head and widen to become invaginated inside the head forming the paraclypeal phragmata (PrPh). At the distal end of the head, is located the labrum (Fig. 1, Lr). The antennae (A) are relatively long, with uniform thickness and bear five short sensory processes at their distal ends.

The larval eyes (LE) are located laterad of the postgenae (PG) on the sides of the head. Each eye is composed of a lunate cephalic part and a more or less rounded caudal part. The submentum (SMt) occupies the meso-caudal area of the ventral aspect. It is separated from the postgenae, on each side, by the submental-postgenal sutures (SPS) on the caudal bends of which are situated the posterior tentorial pits (PT). The submentum is partially divided lengthwise by the median suture (MS), which extends only a short distance cephalad. The median suture has been described

in *Theobaldia incidens* (Thomson) by Cook (1944a). The distal portion of the labium is located in the angle formed between the bases of the maxillae.

The maxillae (Mx) are oval in shape, and are located ventrad of the mandibles (Md). Both the mandibles and the maxillae form the side walls of the mouth opening

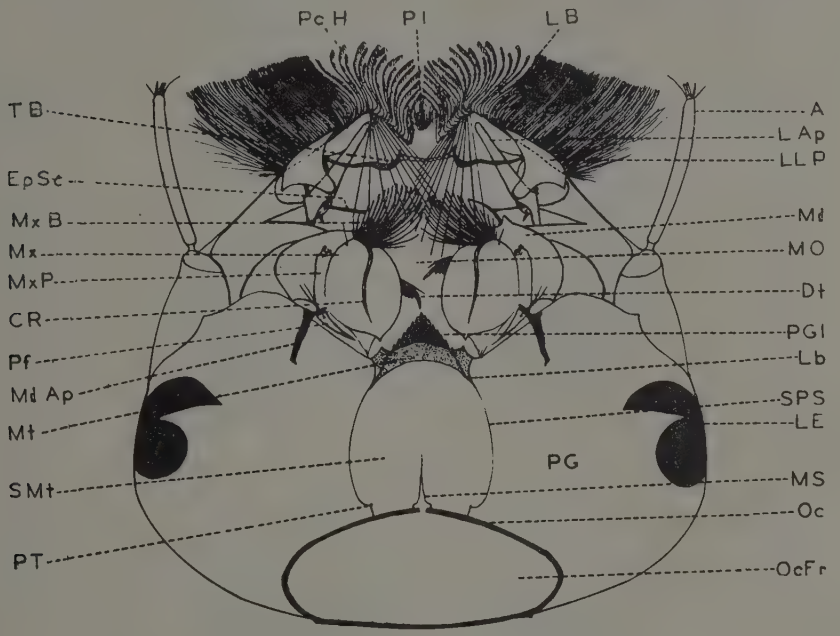


Fig. 1 : Ventral aspect of the head of the fourth instar larva.

(MO). Salem (1931) working on the mouth parts of *Aedes* (*Stegomyia*) *fasciata* (Fab.), referred to the combined structure of the labrum and the epipharynx as the "labrum-epipharynx". On the ental aspect of the labrum is located a group of apodemes (LAp, LLP and TB) to which are attached the muscles that operate the movements of the labrum.

IV. THE MOUTH PARTS OF THE FOURTH INSTAR LARVA

The head capsule of the fourth instar larva of *Aedes aegypti* is about 1.004 mm. in width. The mouth parts are adapted for the grazing feeding habit.

The labrum

The labrum (Fig. 2, Lr) is composed of the disto-median palatum (Figs. 1, 2, and 6, Pl) and the two lateral labral brushes (LB). Arising from the sides of

the preclypeus, and almost from the labro-clypeal suture are two preclypeal hairs (Fig. 2, PrcH) which are relatively long, stout, curved and spine-shaped.

The palatum (Figs. 2 and 6, Pl) is broad and moon shaped, and great number of densely arranged bristle-like palatal hairs (Fig. 2, plH) arise from it. These hairs are long mesad and short laterad. Under high magnification, the palatal hair is relatively short, stout, with a more or less circular base and a serrated distal edge. The ental surface of the palatum is clothed with numerous peculiarly shaped setae, referred to as the ental palatal hairs (Fig. 5, EPlH) which under high magnification, are comparatively long, with a wide base and is divided distally into seven, eight or more branches which make it look like a brush.

The palatum is connected with the labro-clypeal suture (Fig. 2, LCS) by a wide, membranous and flexible area in the shape of an inverted W. Arising from the mesal region of this area and cephalad of the labro-clypeal suture, is a fan-shaped group of fine setae which are referred to as the supra-palatal hairs (SPH). These are numerous, long mesad and short laterad which hang over the palatum, and appear, under high magnifications, to be branched into very fine long branches, which may divide again distad. Attached to the lateral margins of the inverted W shaped flexible area are the triangular shaped hair-bearing sclerites (Figs. 2 and 6, HSc), which bear the labral brushes.

Each labral brush (LB) is fan-shaped and consists of seven groups of setae, which differ in length, location and curvature. The first group of setae is the most lateral and consists of fine, simple and relatively long setae, carried by the proximal extremity of the hair-bearing sclerite. The second group of setae is carried by the proximal third of the hair-bearing sclerite. The setae are very numerous, closely-packed and long. The third group of setae is located meso-cephalad of the second group and is carried by a small portion of the hair-bearing sclerite. It is smaller than the rest of the groups and consists of pectinate hairs (PcH) which are a little shorter than the simple hairs of the second group; however, they have two different lengths, some being a little shorter than the other. The spine-like projections of the pectinate hairs are short and directed mesad, covering only the distal third of the hair. The fourth group of setae is located meso-cephalad of the third group and is borne on the distal third of the hair-bearing sclerite before it curves over the cephalic end of the labral apodeme (Fig. 6, LAp). The hairs of this group are also pectinate. The fifth group of hairs is located mesad of the fourth group and is carried by the distal end which are more or less equal in size, but different in length. All the subgroups are composed of S-shaped pectinate hairs. The pectinate hairs of this group are armed with sharp spiny processes which are longer and sharper than those of the fourth and third groups (Fig. 2 PcH and m., and Fig. 6, PcH). The sixth group of hairs extends caudad on the ental surface of the labrum, and arises from the arched distal part of the hair-bearing sclerite. The hairs of this group are simple, fine and relatively long. The seventh group (Fig. 2) arises from the dorsal side of the hair-bearing sclerite and lies dorsad of the labral brush when the labrum is in the extended position. This

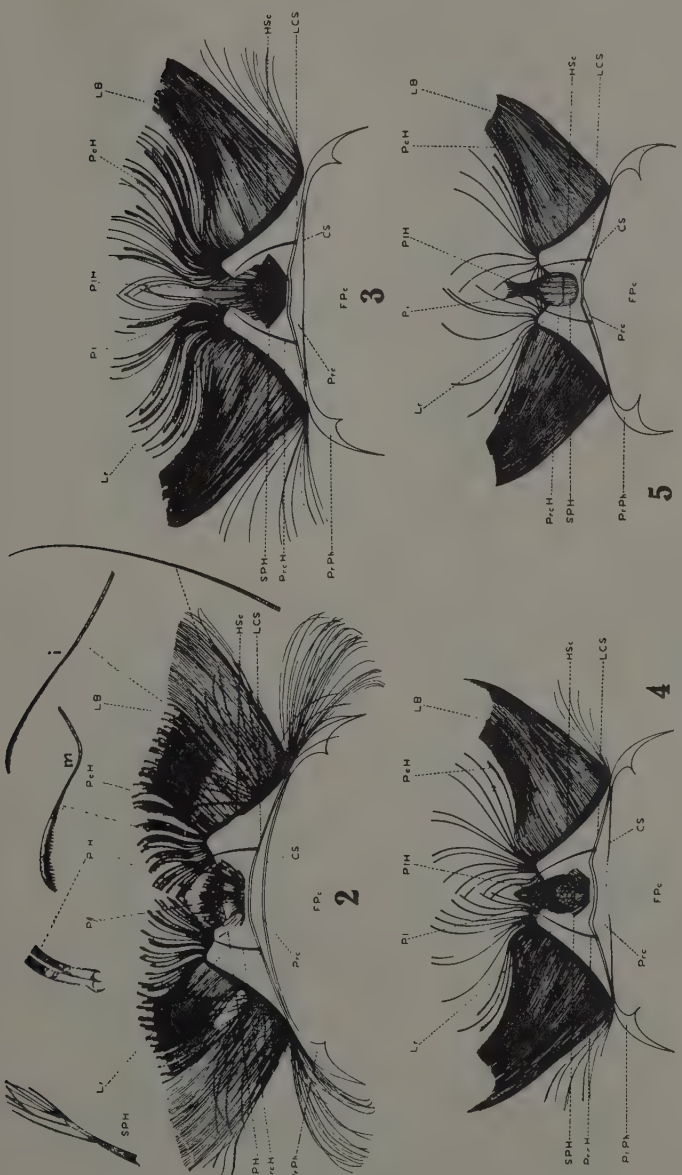


FIG. 2-5 : Dorsal aspect of the cephalic region of the fourth, third, second, and first instar larval head, respectively.

group consists entirely of a few simple and fine hairs. From the previous description, one can conclude that the labral brushes are admirably adapted for the grazing feeding habit of the larva.

The apodemes of the labral brushes are located on the ental surface of the labrum. They are five in number, two labral apodemes, two lateral labral plates and one transverse bar (Fig. 6, LAp, LLP and TB). Each labral apodeme (Figs. 1 and 6, LAp) is located mesad of the hair-bearing sclerite. It is highly sclerotized and heavily pigmented. Connected with the concave lateral margin of the proximal end of the distal third of the labral apodeme and directed laterad, is a more or less triangular process which is referred to as the anterior process of the labral apodeme (Fig. 6, AAp). The middle third is the most dilated, highly sclerotized and heavily pigmented part of the labral apodeme. The proximal third is more or less triangular in shape and narrow. It ends proximad into a pointed and a curved process. The disto-mesal margin of the proximal third is curved sharply laterad and then gradually mesad, leaving a narrow space which is occupied by a membranous area, to which are articulated the lateral extremities of the epipharyngeal sclerite (EpSc). The lateral margin of the proximal third, however, ends distad into a small knob-like structure to which is attached a relatively short and slender spine. The posterior process of the labral apodeme (LAp) is heavily pigmented and extends meso-caudad.

The lateral labral plate (Figs. 1 and 6, LLP) is located in the gap formed between the labral apodeme and the hair-bearing sclerite. It is triangular in shape with a convex lateral margin, convex caudal margin and a concave meso-cephalic margin. The lateral basal part partially covers the meso-ventral area of the hair-bearing sclerite; and the rounded mesal tip lies ventrad of the proximal portion of the middle third of the labral apodeme. The two lateral labral plates may serve to synchronize the movements of the two labral brushes.

The transverse bar (TB) extends horizontally on the ental surface of the labrum. Its lateral extremities are attached to the lateral ends of the anterior processes of the labral apodemes on each side. It is composed of two symmetrical halves that meet each other at the meson. The two halves are highly sclerotized, heavily pigmented, slender laterad and stout mesad. The mesal portion of each half curves cephalad forming a pointed hook-like structure. Adjoining the hook-shaped sclerotized part is a slender, less pigmented and slightly sclerotized part whose mesal end is curved meso-caudad to meet the corresponding part of the other half at the meson.

The epipharynx

The epipharynx (Fig. 6, Ep) forms the roof of the mouth cavity, and covers the entire space between the proximal parts of the labral apodemes (LAp).

The epipharyngeal sclerite (EpSc) extends horizontally between the proximal portions of the labral apodemes, and is pigmented and mesally curved.

Fig. 6-9 : Ventral espect of cephalic region of the fourth, third, second, and first instar larval head, respectively.

The epipharyngeal hairs (EpH) are more complicated in structure than those described by the author in his previous publication on the mouth parts of *Anopheles quadrimaculatus*. For the purpose of description, it will be convenient to divide the hairs into a mesal group, a lateral group, and a caudal group. The mesal group (Fig. 6, a) consists of rigid, spine-like setae which extend meso-caudad. The setae of one side overlap with those of the opposite side along the mesal line forming a sieve-like structure. Under high magnification, each seta divides into two branches, very near their proximal origin, which unite again distad into a single sharply-pointed seta. The lateral group (b) consists of two subgroups of fine simple hairs. The caudal group (c) is attached to the caudal margin of the epipharyngeal sclerite. The part located on one side of the meson is symmetrical with the part of the other side. Each side, however, could be divided into two subgroups, a mesal subgroup and a lateral subgroup. The mesal subgroup is triangular-shaped and consists of relatively rigid and spine-like setae which are directed meso-caudad. The lateral subgroup consists of a relatively small number of long and fine setae which are directed latero-caudad.

The three pairs of epipharyngeal processes (EpP) are connected with the mesal region of the epipharyngeal sclerite. The first pair is H-shaped, with two lateral rod-shaped arms which are connected with each other by a relatively slender transverse arm. Under higher magnifications, the lateral arm is slender and sharply pointed proximad and stout distad. A short spine-like projection can be seen in the angle between the transverse arm and the lateral arms. The other two pairs of the epipharyngeal processes are small, short and are attached to the epipharyngeal sclerite mesad of the H-shaped epipharyngeal process.

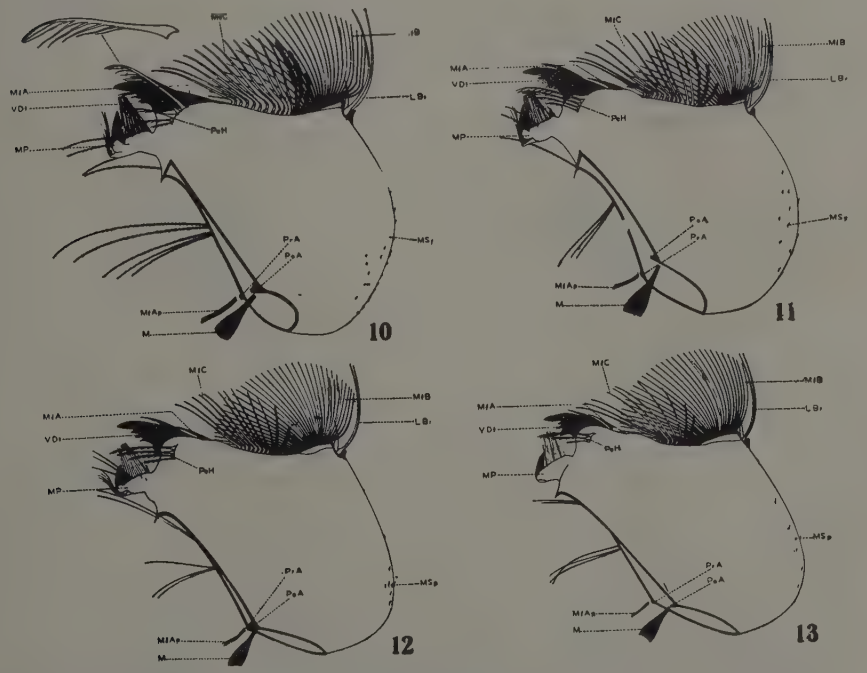
The mandibles

The mandibles (Figs. 10 and 14) are roughly quadrilateral in shape. The dentes-bearing area at the meso-cephalic region of the mandible bears two groups of dentes, a ventral and a dorsal group. The ventral group of dentes (VDt) is composed of four dentes, which consist of a large, stout and somewhat pointed cephalic tooth which extends mesad and three other smaller teeth that are caudad of the cephalic tooth. The dorsal group of dentes (Fig. 14, DDt) is composed of five dentes, which are situated on a more dorsal plane than the ventral dentes, and are seen only from the dorsal aspect. The dorsal dentes could be divided into two sub-groups, a cephalic and a caudal one. The cephalic subgroup consists of one relatively long spine-like tooth which arises from the middle portion of the cephalic margin of the dentes-bearing area. The caudal sub-group of the dorsal dentes is composed of four dentes, two large which overlap at the base and two short and small.

There is a dorsal spine (DSp) which arises from the dorso-lateral region of the dentes-bearing area. It is sharply pointed, of moderate length and extends meso-cephalad. Laterad of the dentes-bearing area there is a relatively long spine-like

arm which has been referred to by FOOTE (1952) working on *Culex* subgenus *Melanoconion*, as the mandibular arm (Figs. 10 and 14, MdA). There are also three short pigmented spines (Fig. 14, Sp) attached to the meso-caudal end of the dentes-bearing area. They are directed mesad.

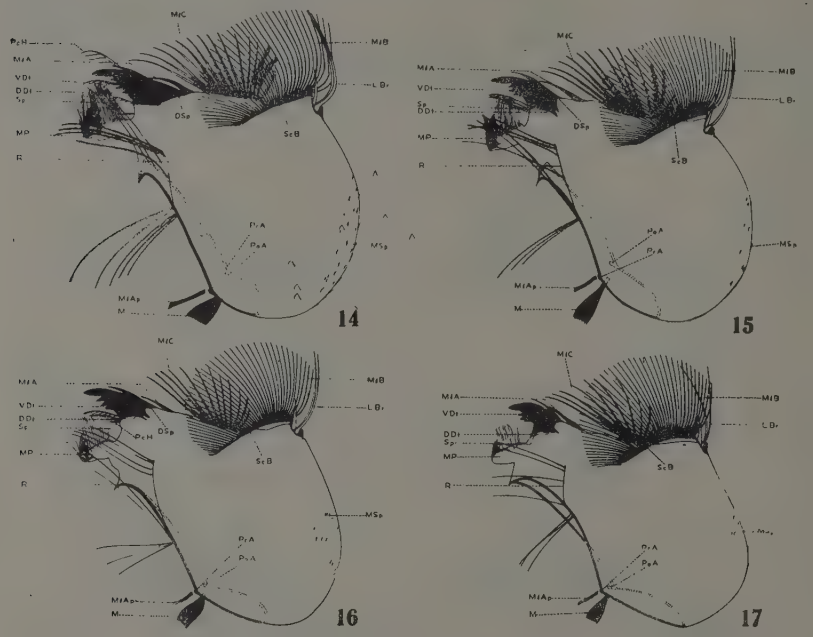
There are six pectinate hairs (Figs. 10 and 14, PcH) which arise from the meso-cephalic region of the mandible caudad of the dentes-bearing area. The cephalic pectinate hairs are stouter and longer than the slender and short caudal hairs. Each hair is pectinate only along the distal two thirds of its mesal margin. Under high magnifications, the branches of the pectinate hairs are fine, flexible and are long distad and short proximad.



FIGS. 10-13 : Ventral aspect of the left mandible of the fourth, third, second, and first instar larva, respectively.

Caudad of the dentes-bearing area and extending mesad is located the membranous process (MP), the cephalic margin of which is slightly convex and ends mesad in a knob-shaped rounded end. There are three groups of hairs which arise from the membranous process : a lateral group which consists of fine and relatively long hairs arising from the cephalic margin of the process; an intermediate

group which consists of slightly rigid and short hairs arising from the knob-shaped mesal end of the process; and a mesal group which consists of numerous, and fine long hairs. This group arises from a short process, caudad of the knob-shaped meso-caudal end of the membranous process.



FIGS. 14-17 : Dorsal aspect of the right mandible of the fourth, third, second, and first instar larva, respectively.

The mesal margins of the mandible are highly sclerotized and pigmented along their entire length. Arising from the middle portion of the mesal margin are fine and long plumose hairs which extend meso-caudad. There is a relatively short and slender ridge (Fig. 14, R) which arises from the proximal end of the distal quarter of the mesal margin and extends cephalad. The ridge, however, is seen only from the dorsal aspect. There are three long plumose hairs arising from the cephalic end of the ridge and directed mesad. From the middle portion of the ridge arises another but short plumose hair. There are three simple hairs also which arise from the proximal portion of the ridge.

The mandible is articulated to the ventral wall of the head capsule by means of the preartis and the postartis (Figs. 10 and 14, PrA and PoA). The mandibular apodeme (MdAp), which is the result of the invagination of the ventral wall of the

head, is attached to the preartis. The abductor muscle (M) is connected with the meso-caudal end of the mandible, close to the postartis.

The lateral margin of the mandible is prominently convex. There is a large number of microspines (MSp) which arise from the proximal two thirds of the lateral region. The distal end of the lateral margin is produced into a sclerotized and pigmented socket-like structure from which arise the lateral bristles (LBr). The lateral bristles are three in number. The most mesal bristle is short and spine-like. The two other bristles are long, curved, flexible and pointed distally.

The mandibular brush (MdB) lies dorsad of the cephalic region of the mandible. It consists of a great number of relatively long setae which are directed meso-cephalad. The setae are longer laterad and shorter mesad. The brush is carried by a sclerite (Fig. 14, ScB) which is continuous laterad with the sclerotized socket bearing the lateral bristles. A comb-like group of setae arises from the middle region of the cephalic margin, which have been referred to as the mandibular comb (Figs. 10 and 14, MdC). This comb is composed of 15 slightly curved, sharply pointed and pigmented stout setae which extend meso-cephalad. The three lateral setae which extend meso-cephalad are plumose. Therefore, the mandibles are admirably adapted for the grazing feeding habit of the larva.

The maxillae

The maxillae (Fig. 18) are located ventrad of the mandibles. Each maxilla is slightly sclerotized and pigmented with the maxillary palpus (MxP) laterad and a large fan-shaped maxillarly brush (MxB) at its cephalic end.

Most of the attempts of the previous workers have failed to reach a satisfactory conclusion in the homology of the maxilla with a generalized type of maxilla. Cook (1944 a), working on the larva of *Theobaldia incidens* (Thomson), wrote describingthe maxillae : "The maxillae are specialized by reduction from the basic type. There are but three parts recognizable : the stipes, which forms the main body, the palpifer and the greatly reduced palpus". Foote (1952), working on the larval morphology of *Culex* subgenus *Melanoconion*, wrote : "The maxilla is composed of three distinct parts : the stipes... forming the main body, the palpifer... which is partially fused to the ventral anterior margin of the anterior lobe, and the reduced palpus". The maxillary palpus and the palpifer are accepted as such by most of the authors. Salem (1931), however, working on the mouth parts of the larva of *Aedes* (*Stegomyia*) *fasciata* (Fab.), considered the palpifer as the second segment of the maxillary palpus. The writer disagrees with Salem (1931) in this concept and agrees with most of the authors regarding the homology of the palpifer and the palpus, but he feels that the homology of the main body as the stipes is incorrect. Comstock (1949), describing the generalized type of maxilla, says : "..., each maxilla consisting, when all of the parts are present, of five primary parts and three appendages. The primary parts are the *cardo* or hinge, the *stipes* or foot-stalk, the *palpifer* or palpus-bearer, the

subgalea or helmet-bearer, and the *lacinia* or blade. The appendages are the *maxillary palpus* or feeler, the *galea* or superior lobe, and the *digitus* or finger.". McGILLIVRAY (1923) terms the spines and hairs arising from the galea, the "galarastra", and the hairs, spines and bristles arising from the lacinia the "lacinarastra".

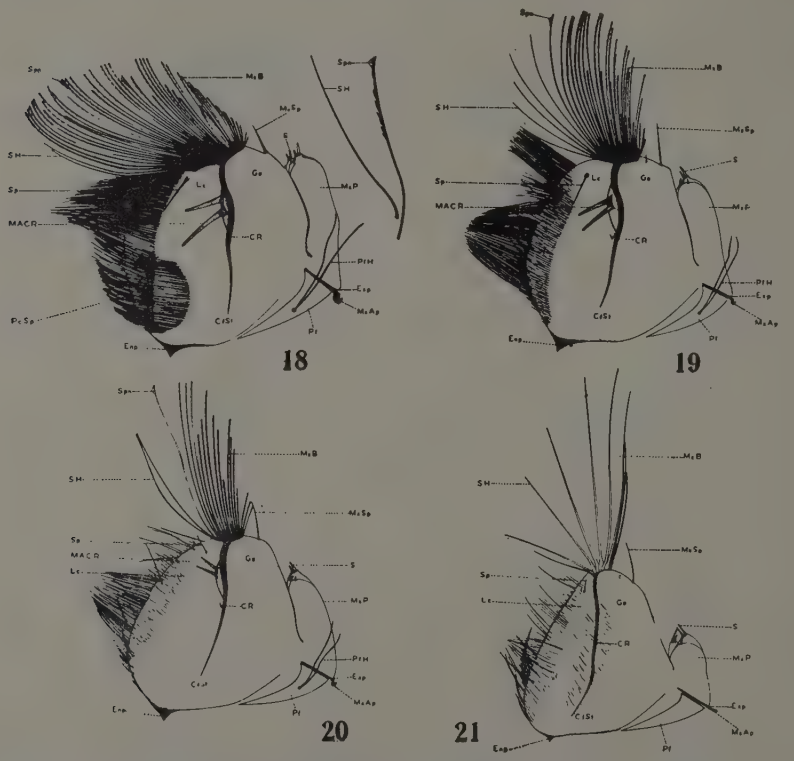


FIG. 18-21 : Ventral aspect of the left maxilla of the fourth, third, second, and first instar larva, respectively.

The writer believes that the stipes of COOK (1944 a) and FOOTE (1952), is actually composed of the fused cardo-stipes (Fig. 18, CdSt) caudad, the lacinia (Lc) disto-mesad, and the galea (Ga) disto-laterad. As the cardo is usually the part of the maxilla which bears the articulating points and assuming that the suture between the cardo and the stipes is obsolete here, then we must have a fused cardo-stipes. The writer believes also that the sutures which separate the stipes caudad from the lacinia and the galea cephalad are obsolete in the maxilla of the mosquito larva. The chitinous ridge (CR) is homologized with the longitudinal suture between

the galea and the lacinia distad and the eustipes and the parastipes caudad in a generalized type of maxilla. The maxillary brush (MxB) at the distal end of the lacinia, is homologized with the lacinarastra. The maxillary spine (MxSp) at the disto-lateral end of the galea can be homologized with the galarastra of other insects.

The maxilla is oval in shape. The mesal margin, from which arise a great number of bristles, setae and spines is prominently convex. The proximal third of the mesal margin is produced into ten or twelve pectinate spines (PcSp), which are rigid, curved and relatively long. From the middle region of the mesal margin, arise five or six relatively long and stout spines, which extend mesad. There is a great number of long fine hairs which tangle and overlap each other along the mesal margin. There is another cluster of hairs which arises from the meso-caudal region of the cardostipes. This cluster consists of very fine and relatively long hairs which extend mesad. The mesal region of the maxilla is well fitted for brushing out and sweeping the food particles inside the mouth cavity.

The chitinous ridge (CR) is stout cephalad, slender caudad, and slightly sinuate. There is a slightly membranous oval area which is attached mesad of the middle region of the chitinous ridge. There are two relatively long and slightly pigmented membranous appendages (MACR) articulating with this oval membranous area. The cephalic appendage is a little shorter than the caudal appendage.

The maxilla is articulated to the ventral wall of the head by means of the entoparartis and the exoparartis (Enp and Exp). The entoparartis is located at the meso-caudal end of the cardostipes, while the exoparartis is located at the caudo-lateral end of the palpus. There is a highly sclerotized and heavily pigmented hook-shaped maxillary apodeme (MxAp) which is connected with the lateral end of the exoparartis. It strengthens the articulation of the maxilla to the head capsule.

The palpifer (Pf) is located caudo-laterad of the cardostipes. It is sclerotized, pigmented and triangular-shaped. The palpifer, here, has been interpreted as a second segment of the palpus by SALEM (1931). There is a single two-branched hair (PfH) which arises from the middle of the ventral surface of the palpifer, with a short stalk.

The palpus is short, small, one-segmented and is attached laterad of the galea (Ga). It is less sclerotized and less pigmented than the rest of the maxilla and on its distal end, there are six very minute papilliform structures which are referred to as the sensoria (S). The sensoria are variable in size and shape.

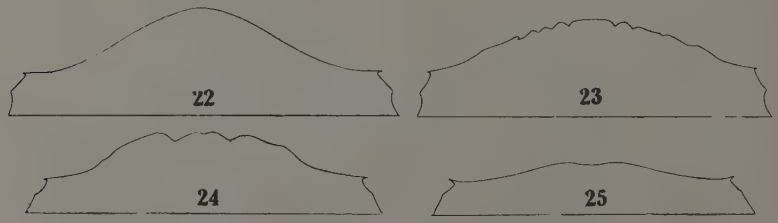
The maxillary brush (MxB), which is located at the cephalic end of the lacinia (Lc), is fan-shaped and consists of a huge number of long hairs. The brush consists of two types of hairs, simple hairs (SH), and spinulated hairs (Spn). The simple hairs are few in number and are located mesad. The major part of the brush consists of spinulated hairs. These are long and stout mesad, and short and slender laterad. Each spinulated hair, as seen under high magnifications, is blunt, rigid and provided with spinulae along the mesal margin of its distal third. Therefore, the maxillary brush is admirably adapted for the grazing feeding habit of the larva.

There is a relatively long and pigmented spine (Sp) attached to the meso-cephalic region of the lacinia. The maxillary spine (MxSp) is of moderate length, pigmented and is attached to the cephalic margin of the galea.

The labium

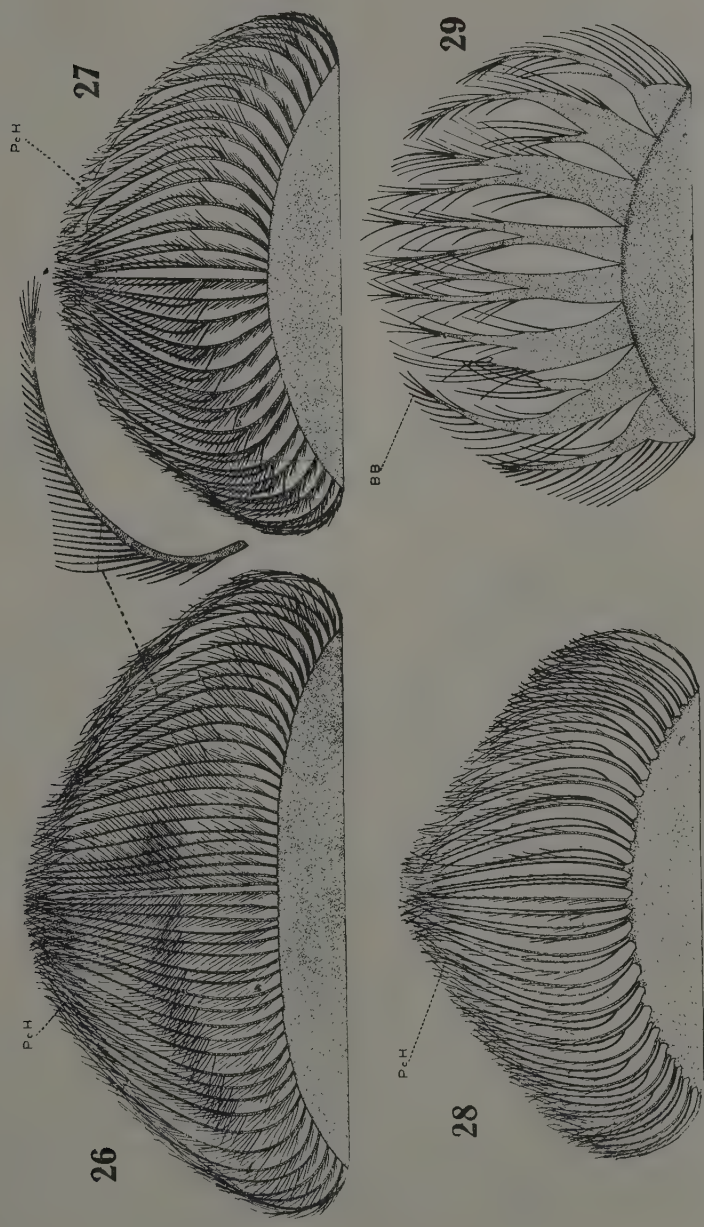
The labium (Fig. 1, Lb) is composed of the submentum, mentum and the prementum. The prementum consists of the glossa and the paraglossa. The submentum (SMt) is an oval-shaped sclerite which covers the meso-caudal area of the ventral aspect of the head. The submentum is partially divided lengthwise by the median suture (MS) which extends a short distance cephalad. The median suture is the result of the incomplete fusion of the second pair of maxillae along the mesal line (Cook, 1944 a). The nomenclature and the homology of the different parts of the labium have been discussed in the previous publication of the author on *Anopheles quadrimaculatus*.

The mentum (Fig. 1, Mt, and Fig. 22) is attached cephalad of the submentum, and is broadly rectangular in shape with a prominently convex cephalic margin. It is more or less membranous and covers the prementum.



Figs. 22-25 : Ventral aspect of the mentum of the fourth, third, second, and first instar larva, respectively.

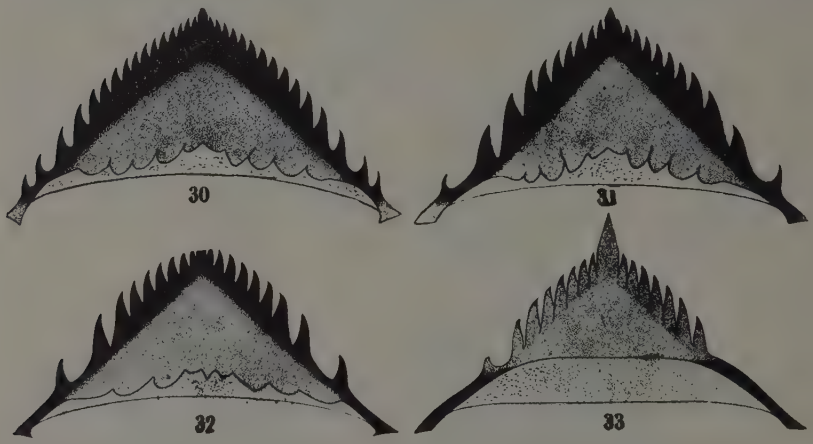
The glossa (Fig. 25) is a narrow and slightly pigmented fringed plate which is located between the mentum and the paraglossa (Fig. 1, PGl). The fringes are in the form of pectinate hairs (Fig. 26, PcH) which arise from the cephalic convex margin of the glossa. The pectinate hairs are long, more or less straight mesad and short and curved laterad. They range from 48 to 52 in number with 24 to 26 pectinate hairs on each side. The fact that the pectinate hairs on one side of the mesal line are symmetrical with those of the other side, may indicate that the glossa is the result of the fusion of the two glossae along the mesal line. Each pectinate hair, under high magnifications, is stout proximad, slender distad and is pectinate only along its lateral margin. The proximal quarter of the pectinate hair is provided with relatively long branches which differ in length. The distal three quarters, however, are provided with longer and more pigmented branches on the lateral margin, which



FIGS. 26-29 : Ventral aspect of the glossa of the fourth, third, second, and first instar larva, respectively.

shorten gradually distad. The distal end of each pectinate hair is divided into a great number of very fine hairs. The shape of the fringed glossa is a significant character for the larva of *Aedes aegypti*.

The paraglossa (Fig. 1, PGl, and Fig. 30.) is a highly sclerotized and heavily pigmented triangular-shaped structure, which is located dorsad of the glossa. It is composed of 32 sharply pointed teeth, 15 on the right side, 16 on the left side and a large disto-central tooth. The proximal teeth, however, are larger than the distal ones. The lateral areas carrying the teeth are the most heavily pigmented and highly sclerotized, while the major medial area is less pigmented and is bounded caudad



FIGS. 30-33 : Ventral aspect of the paraglossa of the fourth, third, second, and first instar larva, respectively.

by a conspicuous curved line. The caudal narrow area is very lightly pigmented. The apparent symmetry of the paraglossa, may indicate that it is formed by the shifting of the two paraglossae dorsad of the glossa and their fusion along the mesal line. It should be mentioned that, the paraglossa and the mandibles constitute the main crushing apparatus in the mosquito larval mouth.

The hypopharynx

The hypopharynx (Fig. 34) is a sclerotized and heavily pigmented rectangular shaped structure which is located dorsad of the paraglossa. It forms the floor of the mouth cavity. The hypopharynx is attached to the cibarial bars (CB) at its cephalo-lateral ends. The cephalic region of the hypopharynx which is enclosed between the bifurcate ends of the cibarial bars, is relatively narrow and more or less membranous. The salivary duct traverses through the hypopharynx and opens dorso-cephalad at the meso-caudal region of the membranous cephalic area (SO). There are two lobe-

like structures (L) located laterad of the cephalic area. Caudad of the cephalic membranous area is located a sclerotized and pigmented medial region (Hyp) which is rectangular in shape. This region is provided with a great number of transverse and oblique ridges forming rectangular and triangular-shaped structures. There are two tooth-like, blunt and heavily pigmented processes at the caudo-lateral end of the hypopharynx which are referred to as the hypopharyngeal processes (HypP). Each hypopharyngeal process arises from a circular pigmented base which is surrounded by a larger membranous area. The hypopharyngeal spines (HypSp) are divided into a cephalic group and a caudal group. The cephalic group consists of seven spines, three on the left side and four on the right side. The caudal group consists of 12 spines, three on each side and six in the middle.

The caudal region of the hypopharynx is occupied by two armed and pigmented lateral lobes, which the writer believes are homologous to the paragnatha in the hypopharynx of the more generalized insects. SNODGRASS (1935) wrote: "in many insects, especially the more generalized forms, the hypopharynx includes a pair of lateral lobes known as the *superlinguae*... which have united with the median part of the hypopharynx, or lingua..., to form the definitive organ.". SNODGRASS (1935), describing the superlinguae, wrote: "The superlinguae of some adult insects have a close resemblance to the paragnatha of certain Crustacea..., and, when the paragnatha are united with the median lingua..., the resulting structure is very similar to the insect hypopharynx... If the paragnatha and the superlinguae are not homologous, they are entirely analogous structures developed in crustacea and insects, but not in the myriapods". The two paragnatha (Pgn) meet each other alongt he meson. Each paragnathus can be differentiated into three regions, a lateral, a mesal and an intermediate region. The lateral region is armed with three sclerotized blade-like structures, provided with spines (LSp). The three spiny blade-like structures are divided into a cephalic, a median and a caudal group. The cephalic group, on both sides consists of eight sharply pointed spines. The median group, which is located caudad of the cephalic group, consists of nine spines which are equal in number to those of the opposite side. The caudal group, on both sides, consists of a relatively long row of short spines, in addition to a considerably long lateral spine.

The intermediate region of each paragnathus is rounded and very lightly pigmented. There are two pairs of lightly pigmented movable spines (MvSp) which arise from this region, on both sides. The mesal region of each paragnathus is more or less crescent-shaped, and fuses with the corresponding region along the mesal line. There are two spines which arise from the mesal region, a small cephalic spine and a relatively large caudal spine.

There is a wing-shaped structure, located caudad of the paragnatha which is heavily pigmented and includes a great number of transverse ridges that look like fibres. There is a group of caudal spines (CSp) which arises from the mesal region of this structure. Two of these spines are blunt and are attached to the meso-

cephalic margin, while the rest are tiny and arranged in three rows at the meso-caudal area.

V. THE MOUTH PARTS OF THE THIRD INSTAR LARVA

The head capsule of the third instar larva of *A. aegypti* is about 0.934 mm. in width. This larva has the same grazing feeding habit as the larva of the fourth instar.

The labrum

The labrum (Fig. 3, Lr) is composed, as in the fourth instar, of the median palatum and the lateral labral brushes. The clypeal suture (CS) which separates the preclypeus (Prc) from the fronto-postclypeus (FPc) is thinner than that of the fourth instar and particularly mesad. The preclypeus is relatively narrower, less pigmented and less sclerotized than that of the fourth instar.

The palatum (Figs. 3, and 7, pl) is in the shape of half a circle, while that of the fourth instar is moon-shaped. The palatal hairs arising from the ectal surface of the palatum are proportionally long. The ental palatal hairs (Fig. 7, EPlH), however, are fewer than those of the fourth instar. The supra-palatal hairs (Fig. 3, SPH) consist of shorter and fewer hairs than those of the fourth instar.

The labral brushes (Figs. 3 and 7, LB) are smaller but proportionally longer than those of the fourth instar. Each brush consists of six groups of hairs, while that of the fourth instar is composed of seven groups. The first group arises from the caudo-lateral end of the hair-bearing sclerite (HSc). It consists of entirely simple hairs. The second group consists of simple hairs too, and arises from the caudo-lateral third of the hair-bearing sclerite. The third group consists of pectinate hairs (PcH) intermixed with simple hairs, while that of the fourth instar consists only of pectinate hairs. The fourth group which arises from the meso-cephalic portion of the hair-bearing sclerite is less dense than that of the fourth instar and consists of entirely pectinate hairs. The fifth group is subdivided into five subgroups, as in the fourth instar. Each subgroup is composed of pectinate hairs intermixed with simple hairs, with a noticeable reduction in the number of pectinate hairs in the subgroups towards the meson. The most mesal subgroup consists entirely of simple hairs. The sixth group of hairs in this instar arises from the arched cephalic end of the hair-bearing sclerite. It is composed of relatively long simple hairs, which are less dense than in the fourth instar. The seventh group, present in the fourth instar, is absent in the third instar.

The apodemes of the labral brushes are similar to those of the fourth instar. The labral apodeme (Fig. 7, LAp) is elongated, slender and less sclerotized than that of the fourth instar. The anterior and the posterior processes (AAp and PAp)

are similar to those of the fourth instar. The triangular-shaped lateral labral plate (LLP) is less sclerotized and less pigmented than that of the fourth instar. The transverse bar (TB) is short and lightly sclerotized. The lateral extremities of the transverse bar fit in the lateral margin of the labral apodeme at the point where the cephalic end of the anterior process of the labral apodeme articulates with it.

The epipharynx

The epipharynx is similar in shape to that of the fourth instar. The epipharyngeal sclerite (EpSc) is lightly pigmented and slightly sclerotized. The epipharyngeal hairs (EpH) are less dense than those of the fourth instar. The spine-like mesal group of the epipharyngeal hairs (Fig. 7, a) are eight in number, four on each side of the meson, while those of the fourth instar are ten in number, five on each side of the meson. The lateral group (b) of the epipharyngeal hairs is subdivided into a mesal and a lateral subgroup, with less dense and shorter hairs. The caudal group of the epipharyngeal hairs (c) is subdivided into two subgroups, the hairs of which are shorter and fewer than those of the fourth instar.

The three pairs of epipharyngeal processes (Fig. 7, Ep) are smaller, less sclerotized and less pigmented than those of the fourth instar.

The mandibles

The mandibles (Figs. 11 and 15) are quadrangular in shape. Each mandible is smaller in size than that of the fourth instar. The dentes-bearing area bears both the ventral and the dorsal group of dentes. The ventral dentes (VDt) are four in number, as in the fourth instar. The dorsal group of dentes (DDT) consists of four dentes, while that of the fourth instar consists of five dentes. The dorsal spine (Fig. 15. DSp) which arises from the cephalo-lateral end of the dentes-bearing area and lies dorsad of it, is more slender and a little shorter than that of the fourth instar. The mandibular arm (Figs. 11 and 15, MdA) is also a little shorter and less pigmented than that of the fourth instar. The pectinate hairs (Fig. 11, PcH) are slender and slightly pigmented. They are four in number, while there are six in the fourth instar.

The membranous process (Figs. 11 and 15, MP) bears three groups of setae which are finer, and shorter than those of the fourth instar. The mesal margin of the mandible is sclerotized and pigmented along its entire length. There are five relatively long plumose setae which arise from the middle region of the mesal margin, as in the fourth instar. The ridge (Fig. 15, R) which arises from the proximal end of the distal third of the mesal margin on the dorsal aspect of the mandible is longer than that of the fourth instar. The three simple setae arising from both the mesal margin and the ridge in the fourth instar are absent in the third instar. The mandible is articulated to the ventral wall of the head by the preartis and the postartis (Figs.

11 and 15, PrA and PoA). The articulation is strengthened by the mandibular apodeme (MdAp) as in the fourth instar. The abductor muscle (M) is attached to the meso-caudal end of the mandible, close to the postartis.

The microspines (MSp) which arise from the lateral region of the mandible are fewer than those of the fourth instar. The lateral bristles (LBr) are located at the distal end of the lateral margin. The mandibular brush (MdB) is a little smaller than that of the fourth instar. The mandibular comb (MdC) is composed of 14 bristles, while that of the fourth instar is composed of 15 bristles. The most lateral three bristles of the mandibular comb are plumose.

The maxillae

The maxillae (Fig. 19) are smaller in size, less sclerotized and less pigmented than those of the fourth instar. Each maxilla is composed of the cardostipes (CdSt), lacinia (Lc), galea (Ga), palpifer (Pf) and the maxillary palpus (Mxp). The spines, bristles and hairs which arise from the convex mesal margin of the maxilla are fewer and less dense than those of the fourth instar. The pigmented pectinate spines which arise from the caudal region of the mesal margin of the fourth instar (Fig. 18, PcSp) are absent in the third instar. The chitinous ridge (Fig. 19, CR) is more slender and a little shorter than that of the fourth instar. The membranous appendages of the chitinous ridge (MACR) are comparatively short.

The maxilla is articulated to the ventral wall of the head by the entoparartis (Enp) mesad, and the exoparartis (Exp) laterad. The maxillary apodeme (MxAp) strengthens the articulation of the maxilla to the head. The palpifer (pf) is smaller and less pigmented than that of the fourth instar. The branched hair (PfH) arising from the palpifer is comparatively short.

The maxillary palpus (MxP) is more slender and less pigmented than that of the fourth instar. It bears at its distal end five sensoria (S) while there are six in the fourth instar. It must be noted, however, that there are variations in the number of the sensoria among different specimens. The maxillary spine (MxSp) is more slender and proportionally longer than that of the fourth instar. The maxillary brush (MxB) is fan-shaped and is conspicuously smaller than that of the fourth instar. It is composed of simple hairs (SH) and spinulated hairs (Spn). The simple hairs are relatively more numerous than those of the fourth instar. The spinulated hairs are shorter and less dense than those of the fourth instar.

The labium

The labium is composed of the same parts of the fourth instar. There is no illustration, here, for the submentum because of its similarity to that of the fourth instar.

The mentum (Fig. 23) is narrow, slightly membranous and lightly pigmented. Its cephalic margin is sinuous, while that of the fourth instar is evenly convex.

The glossa (Fig. 27) is slightly pigmented, fringed and narrower than that of the fourth instar. These fringes range from 32 to 36 pectinate hairs (PcH), with 16 to 18 on each side of the mesal line. The pectinate hairs of the glossa of the fourth instar range from 48 to 52 in number. It must be noted that the pectinate hairs of the third instar are branched and not so in the fourth instar. There is one branch which arises from the middle of the pectinate hair and extends meso-cephalad.

The paraglossa (Fig. 31) is triangular in shape. It is smaller, less sclerotized and less pigmented than that of the fourth instar. It is composed of 22 teeth, 10 on the left side, 11 on the right side and one disto-central tooth. Both sides of the paraglossa, however, look perfectly symmetrical. In the fourth instar, the paraglossa consists of 32 teeth (Fig. 30). There have been several variations in the number of the teeth of the paraglossa among different specimens.

The hypopharynx

The hypopharynx (Fig. 35) is similar to that of the fourth instar, but smaller in size. The transverse and oblique ridges of the hypopharynx (Hyp) which form the rectangular, triangular and trapezoidal shaped structures are fewer than those of the fourth instar. The rounded membranous area which surrounds the hypopharyngeal process (HypP), in the fourth instar is here absent. The cephalic group of the hypopharyngeal spines (HypSp) consists of six spines, while there are seven in the fourth instar. The caudal group is composed of nine spines, while that of the fourth instar is composed of 12 spines.

The paragnatha (Pgn) are similar in structure to those of the fourth instar. The cephalic blade-like structure of the lateral region of the paragnathus consists of six spines on the right side, while that of the left paragnathus consists of seven spines (LSp). That of the fourth instar, however, consists of eight spines on both sides. The intermediate blade-like structure consists of six spines on each side, while that of the fourth instar consists of nine spines on each side. The caudal spiny structure is composed of a fewer number of spines than that of the fourth instar. The movable spines (MvSp) of the intermediate region of the paragnathus are somewhat pointed and a little shorter than those of the fourth instar. The mesal regions of the paragnatha contain six small spines, three on each side, while there are four in the fourth instar, two on each side. The caudal spines (CSp) consist only of two blunt spines at the meso-caudal region of this area. The three rows of caudal spines, in the fourth instar, are here absent.

VI. THE MOUTH PARTS OF THE SECOND INSTAR LARVA

The head capsule of the second instar larva is about 0.703 mm. in width. The larva in this instar has the grazing feeding habit also.

The labrum

The labrum (Fig. 4, Lr) is composed of the palatum and the labral brushes. The clypeal suture (CS) is very slender and differs from that of the third and fourth instars in being obsolete mesad. The preclypeal hairs (PrcH) are relatively long and more slender than those of the third and fourth instars. The paraclypeal phragmata (PrPh) are small and slightly pigmented.

The palatum (Figs. 4 and 8, Pl) is smaller than in the older instars. The palatal hairs (Fig. 4, PlH) are finer, fewer and a little shorter than those of the third instar. The ental palatal hairs are absent in this instar. The supra-palatal hairs (SPH) are finer and less dense than those of the third and fourth instar.

The labral brushes (Figs. 4 and 8, LB) are relatively shorter and less dense than those of the third instar. Each labral brush is composed of six groups of hairs as in the third instar, while there are seven groups in the fourth instar. The first group is composed of a few, simple and short hairs, which are attached to the caudo-lateral edge of the hair-bearing sclerite (HSc). The second group is composed of simple hairs also. The third group is composed of simple hairs intermixed with pectinate hairs (PcH). The fourth group consists entirely of pectinate hairs which are less dense and a little shorter than those of the third instar. The fifth group arises from the arched distal end of the hair-bearing sclerite. It is composed of simple hairs, while those of the third instar are composed of intermixed simple and pectinate hairs, and those of the fourth instar are composed entirely of pectinate hairs. In this instar, the fifth group is not subdivided into subgroups, thus differing from the older instars. The sixth group extends meso-caudad on the ental surface of the labrum. It is composed of fewer, finer and somewhat shorter hairs than those of the third and fourth instar.

The elongated labral apodeme (Fig. 8, LAp) is less sclerotized and less pigmented than in the older instars. Both the anterior and the posterior processes of the labral apodeme (AAp and PAp) are present, in addition to a median process (MAp) which is absent in both the third and the fourth instars. The median process is a small protrusion attached to the median third of the labral apodeme and extends mesad. The lateral labral plate (LLP) is small, lightly sclerotized and slightly pigmented. In this instar, the two symmetrical halves of the transverse bar (TB) do not meet at the meson. They are connected at the meson by means of a short, slender and membranous transverse area, thus differing from the older instars.

The epipharynx

The epipharynx (Ep) does not cover the whole area between the proximal thirds of the labral apodemes. The epipharyngeal sclerite (EpSc) is more slender and less pigmented than that of the third instar. The epipharyngeal hairs (EpH) are few and fine. The mesal group of the epipharyngeal hairs (Fig. 8,a) consists

of eight hairs, four on each side as in the third instar, while in the fourth instar there are ten, five on each side. The hairs of the mesal group are similar in construction to those of the advanced instars. The lateral group of epipharyngeal hairs (b) is composed of fewer, finer and shorter hairs than those of the third and fourth instars. The caudal group (c) consists of fewer and finer hairs than in the advanced instars. The epipharyngeal processes (Fig. 45, EpP) are similar to those of the older instars, although they are smaller and less pigmented.

The mandibles

The mandibles (Figs. 12 and 16) are smaller in size, less sclerotized and less pigmented than those of the third and fourth instars. The ventral group of dentes (VDt) are four in number as in the advanced instars. The dorsal dentes (Fig. 16, DDt) are four in number as in the third instar, while there are five dentes in the fourth instar. The dorsal spine (DSp) is slender and short. The mandibular arm (MdA) is sharply pointed and is shorter than that of the advanced instars. The pectinate hairs (Fig. 12, PcH) are short, slender and are four in number. The three small spines, at the meso-caudal end of the dentes-bearing area are less prominent than those of the older instars.

The membranous process (Figs. 12 and 16, MP) is comparatively short and its mesal margin is prominently cleft. The three groups of hairs arising from the membranous process consist of shorter, finer and fewer hairs than those of the third and fourth instars. The mesal margin of the mandible is sclerotized along its entire length. The five setae arising from the middle of the mesal margin are short and simple, while those of the third and fourth instars are long and plumose. The ridge (Fig. 16, R) is comparatively slender. The four setae arising from that ridge are short and simple, while those of the older instars are long and plumose.

The mandible is articulated to the ventral wall of the head by means of the preartis (Fig. 12 and 16, PrA) and the postartis (PoA). The articulation is strengthened by the help of the mandibular apodeme (MdAp). The microspines (MSp) arising from the lateral region of the mandible are fewer than those of the third and fourth instars. The lateral bristles are three in number (LBr) as in the older instars. They are comparatively slender and short.

The mandibular brush (MdB) is smaller than that of the third, and fourth instars. The mandibular comb (MdC) is composed of 12 slender bristles with two lateral short plumose bristles. The mandibular comb of the third instar consists of 14 bristles, with three lateral plumose bristles, and that of the fourth instar consists of 15 bristles with three lateral plumose bristles.

The maxillae

The maxillae (Fig. 20) are comparatively small in size. Each maxilla is composed of the same sclerites which have been mentioned previously in the advanced

instars. The chitinous ridge (CR) is comparatively short and slender. The membranous appendages of the chitinous ridge (MACR) are short and slender. The spines, hairs and setae which arise from the mesal margin are fewer than those of the advanced instars. The pectinate spines arising from the caudal area of the mesal margin in the fourth instar, are here absent as well as in the third instar.

The maxilla is articulated to the ventral wall of the head by means of the entoparartis (Enp) mesad, and the exoparartis (Exp) laterad. The articulation is strengthened by the hook-shaped maxillary apodeme (MxAp). The palpifer (Pf) is smaller in size and less pigmented than that of the third and fourth instars. The two-branched hair (PfH) is present but short. The maxillary palpus (Mxp) is short and slightly pigmented. It bears at its cephalic end five sensoria (S) as in the third instar, while there are six sensoria in the fourth instar.

The maxillary brush (MxB) is less dense than that of the third and fourth instars. The hairs of the brush are short and light in colour. They consist of simple hairs (SH) and spinulated hairs (Spn). The maxillary spine (MxSp) which is attached to the cephalic margin of the galea (Ga) is flexible and more slender than that of the older instars. The spine (Sp) which arises from the lacinia (Lc) is comparatively short and slender.

The labium

The labium is composed of the same parts described in the fourth instar. The submentum is similar to that of the third and fourth instars but smaller in size.

The mentum (Fig. 24) is narrower and more membranous than those of the older instars. The cephalic margin is less sinuate.

The glossa (Fig. 28) is smaller in size than that of the third and fourth instars. The fringes which arise from the cephalic margin range from 28 to 32 pectinate hairs (PcH), with 14 to 16 hairs on each side of the mesal line. It must be noted also that the pectinate hairs of this instar are compound, since they have two branches on each. Those of the third instar have only one branch, while those of the fourth instar are not branched.

The paraglossa (Fig. 32) is smaller in size, less sclerotized and less pigmented than that of the older instars. It consists of 19 teeth, nine on each side of the disto-central tooth. The lateral, most heavily pigmented areas which carry the teeth are narrower than those of the older instars. The median lightly pigmented area is relatively wider than that of the advanced instars. It is bounded caudad by a strongly sinuate line. The caudal area of the paraglossa is more or less membranous.

The hypopharynx

The hypopharynx (Fig. 36) is comparatively small in size. The salivary opening (SO) can only be seen clearly under the higher magnifications of the compound

microscope. The triangular and quadrangular shaped structures which are formed by the ridges in the middle region of the hypopharynx are fewer than those of the older instars. The hypopharyngeal processes (HypP) are shorter and less pigmented than those of the third and fourth instars. The cephalic group of the hypopharyngeal spines (HypSp) are four in number, two on each side of the meson. The caudal group consists of seven spines, four on the left side and three on the right side.

The paragnatha (Pgn) are smaller than those of the advanced instars. The cephalic blade-like structures of the lateral regions of the paragnatha consist of nine spines (LSp), four spines on the left paragnathus and five on the right. The median blade-like structures consist of eight lateral spines, four spines on each side. The caudal blade-like structure of each paragnathus consists of one relatively large spine and a row of minute spines which are fewer than those of the older instars. The movable spines (MvSp) of the intermediate regions of the paragnatha are short, lightly pigmented and are four in number, two on each side. Each mesal region of the paragnatha carry only one small spine. The caudal spines (CSp) consist only of two blunt and small spines, similar to those of the third instar, while those of the fourth instar are large in addition to three rows of small spines.

VII. MOUTH PARTS OF THE FIRST INSTAR LARVA

The head of the first instar larva is about 0.335 mm. in width. It is characterized by the presence of the egg burster (Fig. 38, EB) on the dorsal aspect of the head. The first instar larva has the same grazing feeding habits as those of the advanced instars.

The egg burster (Fig. 38, EB) which is situated in the middle of the frons (F), is oval in shape, more elongate than wide, and very conspicuous. It has a pigmented more or less rounded area, with an elongated and somewhat pointed caudal region. A heavily pigmented spine is attached to the meso-cephalic region of this rounded area. A narrow, membranous and lightly pigmented area surrounds the egg burster. The egg burster helps in breaking the chorion of the egg during the harching process.

The labrum

The labrum (Fig. 5, Lr) is composed of the palatum and the labral brushes. The preclypeus (Prc) in this instar is divided by an interrupted clypeal suture (CS), in two parts. The two parts of the clypeal suture extend meso-cephalad to meet the labro-clypeal suture shortly before the mesal line. The preclypeal hairs (PrcH) are more flexible and more slender than those of the second instar.

The palatum (Figs. 5 and 9, Pl) is roughly oval in shape, while that of the second instar is triangular in shape. The palatal hairs (Fig. 5, PlH) are longer laterad and shorter mesad. The ental palatal hairs are absent also in this instar. The supra-

palatal hairs (SPH) are fewer, finer and relatively longer than those of the second instar. They form an oval shaped structure while those of the advanced instars are fan shaped.

The labral brushes (Figs. 5 and 9, LB) are less dense and relatively shorter than those of the second instar. Each labral brush is composed of four groups of hairs only. The first group consists of simple hairs which arise from the proximal half of the hair-bearing sclerite (HSc). The second group consists of pectinate hairs (Fig. 5, PcH) which arise from the distal portion of the hair-bearing sclerite. The third group consists of simple hairs, and arises from the arched distal end of the hair-bearing sclerite. The fourth group consists of a few and fine simple hairs which extend meso-caudad on the ental aspect of the labrum.

The elongated labral apodeme (Fig. 9, LAp) is more slender, lightly pigmented, and less sclerotized than that of the second instar. The anterior, medial and posterior processes of the labral apodeme (AAp, MAp and PAp) are present. The medial process, however, is more prominent than that of the second instar, while being absent in the third and fourth instars. The triangular-shaped lateral labral plate (LLp) is smaller in size, less sclerotized and less pigmented than that of the advanced instars. The transverse bar (TB) is slender. The two symmetrical halves do not meet each other at the meson, thus differing from those of the advanced instars.

The epipharynx

The epipharynx (Ep) is composed of the epipharyngeal sclerite (EpSc) and the epipharyngeal hairs (EpH). The three epipharyngeal processes which have been described in the advanced instars, are absent in this instar. The epipharyngeal sclerite is slender and short. The epipharyngeal hairs are all simple, fine and short, thus differing from those of the advanced instars.

The mandibles

The mandibles (Figs. 13 and 17) are smaller in size, less sclerotized and more lightly pigmented than those of the advanced instars. The ventral group of dentes (VDt) consists of five dentes, while there are four ventral dentes in the older instars. The dorsal group of dentes (Fig. 17, DDt) consists of four small dentes. The dorsal spine which has been described in the second, third and fourth instars is absent in the first instar. The mandibular arm (Fig. 13 and 17, MdA) is very flexible and lightly pigmented. The pectinate hairs (Fig. 13, PcH) are only three in number.

The membranous process (Fig. 13 and 17, MP) is shorter than that of the second instar. The cleft which divides the mesal margin of the membranous process in the older instars is absent in the first instar. There are only two groups of fine and relatively long hairs which arise on the cephalic margin of the process, while

there are three in the advanced instars. The mesal margins of the mandible are sclerotized along their entire length. Arising from the middle of the mesal margin are three simple hairs only, while there are five in the older instars. The ridge (Fig. 17, R) is short and slender, from which arise four simple setae.

The mandible is articulated to the ventral wall of the head by means of the preartis and the postartis (Figs. 13 and 17, PrA and PoA). The microspines (MSp) arising from the lateral region of the mandible are fewer and smaller than those of the older instars. The three lateral bristles (LBr) are relatively long, slender and flexible. The mandibular brush (MdB) consists of fewer setae than those of the advanced instars. The mandibular comb (MdC) consists of ten bristles, having the two most lateral bristles plumose.

The maxillae

The maxillae (Fig. 21) are smaller in size, and more lightly pigmented than those of the advanced instars. The chitinous ridge (CR) is comparatively slender. The two membranous appendages of the chitinous ridge are absent. The setae and the spines, arising from the mesal margin are less dense than those of the second instar. The pectinate spines which arise from the caudal region of the mesal margin of the maxilla of the fourth instar are also absent in the first instar.

The maxilla is articulated to the wall of the head by means of the entoparartis and the exoparartis (Enp and Exp). The palpifer is small in size, lightly sclerotized and slightly pigmented. The two-branched hair which arises from the palpifer of the second, third and fourth instars, is absent in this instar. The maxillary palpus is comparatively short. It bears six relatively long sensoria (S) at its distal end. The lateral margin of the maxilla is provided with very minute and pigmented serrations which are not present in the older instars. The maxillary spine (MxSp) which is attached to the cephalic margin of the galea (Ga) is relatively long and slender.

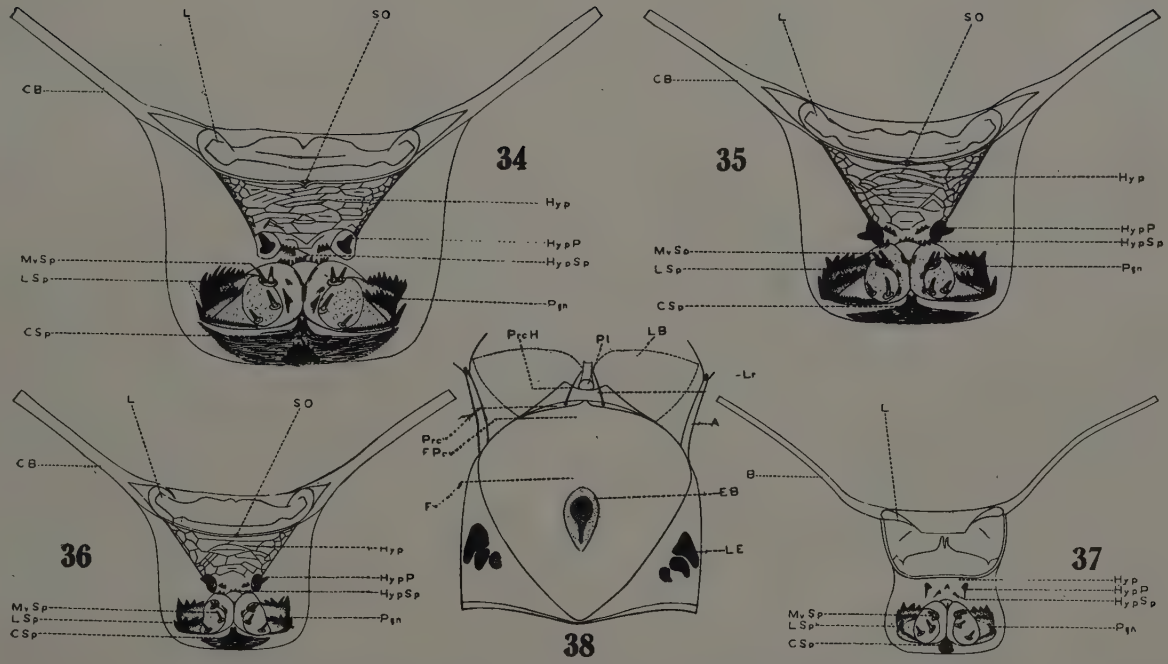
The maxillary brush (MxB) differs from those of the advanced instars, since it consists of only simple hairs (SH). The absence of the spinulated hairs presents an important taxonomic character. The brush consists of nine to twelve hairs. The spine (Sp) which is attached to the lacinia (Lc) is shorter and more slender than that of the second instar.

The labium

The labium is composed of the same parts of the advanced instars. There is no illustration here, for the submentum because of its similarity to that of the fourth instar, with the exception of the size.

The mentum (Fig. 25) is narrower and more membranous than that of the second instar. The cephalic margin of the mentum is less sinuate than that of the second and third instars.

The glossa (Fig. 29) is unique in its shape due to the tree-shaped branched bristles (BB) which form its fringes. These fringes consist of eight branched bristles,



FIGS. 34-37 : Ventral aspect of the hypopharynx of the fourth, third, second, and first instar larva, respectively. — FIG. 38: Dorsal aspect of the head of the first instar larva showing the egg burster (EB) in the middle of the frons.

four on each side of the mesal line. The author believes that these eight bristles multiply by division during the course of development after each moult, forming the pectinate hairs of the older instars.

The paraglossa (Fig. 33) is smaller, less sclerotized and less pigmented than that of the advanced instars. Out of 11 specimens which have been dissected, six specimens have the paraglossa with 16 teeth, eight on the left side, seven on the right side and an extremely large disto-central tooth. One specimen has the paraglossa with 16 teeth, seven on the left, eight on the right and an extremely large disto-central tooth. Four specimens have the paraglossa with 15 teeth, seven teeth on each side of the large disto-central tooth. The median area of the paraglossa is slightly pigmented and is bounded caudad by a horizontal straight line. The caudal area, however, is relatively larger and more membranous than that of the second instar.

The hypopharynx

The hypopharynx (Fig. 37) is smaller in size, less sclerotized and less pigmented than that of the advanced instars. The cephalic half of the hypopharynx is relatively larger but less pigmented than that of the second instar. The salivary opening is not apparent in the first instar. Instead, there are two mesal papilliform processes which extend cephalad. It should be noticed that the area containing the transverse and oblique ridges in the older instars, is absent in the first instar. The hypopharyngeal processes (HypP) are comparatively small and slender. The hypopharyngeal spines (HypSp) are only three in number.

The paragnatha (Pgn) are small, slightly sclerotized and lightly pigmented. The cephalic blade-like structures of each paragnathus consist of six lateral spines (LSp), three on each side. The intermediate blade-like structures consist of seven spines, three on the left side and four on the right side. The caudal blade-like structures consist of a row of very minute spines which are fewer in number than those of the advanced instars. The movable spines (MvSp) which are carried by the intermediate oval region of the paragnathus are three in number. The mesal regions of the paragnatha include no spines in this instar. The caudal spines which have been described in the older instars are absent in the first instar.

VIII. SUMMARY OF THE IMPORTANT INSTAR DIFFERENCES

The *labral brushes* of the first instar (Figs. 5 and 4, LB) are composed of four groups of hairs each. The mesal group of hairs consists of a few and entirely simple hairs. The labral brush of the second instar (Figs. 4 and 8, LB) consists of six groups of hairs, the mesal group of which, consists of a greater number of simple hairs. That of the third instar (Figs. 3 and 7, LB) is composed of six groups of hairs, with the mesal group divided into five subgroups, each of which consists of simple hairs intermixed with pectinate hairs. The labral brush of the fourth instar (Figs. 2 and 6,

LB) is composed of seven groups of hairs, with the mesal group divided into five subgroups, each of which consists of entirely pectinate hairs.

The *clypeal suture* of the first instar (Fig. 5, CS) is composed of two parts that extend meso-cephalad to meet the labro-clypeal suture (LCS) shortly before the meson, thus leading to the division of the preclypeus (Prc) into two parts. The clypeal suture of the second instar (Fig. CS) extends mesad, but fades gradually and becomes more or less obsolete at the meson. The clypeal sutures of the third and fourth instars (Figs. 2 and 3, CS) are quite distinct.

It should be observed that the first instar is distinguished by the presence of the egg burster (Fig. 38, EB) on the dorsal aspect of the head.

The *epipharyngeal hairs* of the first instar (Fig. 9, EpH) are all simple, and fine. The epipharyngeal processes are absent in the first instar, and present in the older instars. The epipharyngeal hairs of the second instar (Fig. 8, EpH) are divided into three groups, the mesal group of which (a) consists of eight spine-like setae. The epipharyngeal hairs of the third instar (Fig. 7, EpH) are similar in structure tothose of the second instar but numerous. Those of the fourth instar (Fig. 6, EpH) are similar to those of the third instar, with the mesal group (a) consisting of ten long spine-like setae instead of eight.

The *ventral dentes* of the mandible of the first instar (Figs. 13 and 17, VDt) are five in number, while they are four in number in the older instars.

The *mandibular comb* of the first instar (MdC) consists of ten slender bristles, with two lateral plumose bristles. That of the second instar (Figs. 12 and 16, MdC) is composed of 12 bristles, with two lateral plumose bristles. The mandibular comb of the third instar (Figs. 11 and 15, MdC) is composed of 14 bristles, with three lateral plumose bristles. That of the fourth instar (Figs. 10 and 14, MdC) consists of 15 stout bristles, with three lateral plumose bristles.

The *maxillary palpus* of the first instar (Fig. 21, MxP) is short and reaches only to half the distance of the lateral margin of the maxilla. The palpus elongates after each moult until it reaches as far as the cephalic margin of the galea in the fourth instar (Fig. 18, MxP).

The *palpifer* of the first instar (Fig. 21, Pf) bears no setae. These of the advanced instars bear a two-branched seta.

The *maxillary brush* of the first instar (MxB) consists of 12 simple hairs. Those of the second, third and fourth instars include spinulated hairs together with the simple hairs. The spinulated hairs, however, increase in number after each moult.

The *glossa* of the first instar (Fig. 29) is provided with eight tree-shaped branched bristles. That of the second instar (Fig. 28) is provided with 28 to 32 pectinate hairs, with at least two branches each. The glossa of the third instar (Fig. 27) is provided with 32 to 36 pectinate hairs, with not more than one branch each. The glossa of the fourth instar (Fig. 26) is provided with 48 to 52 unbranched. hairs.

The *paraglossa* of the first instar (Fig. 33) is composed of 16 teeth while that of the second instar (Fig. 32) is composed of 19 teeth. The paraglossa of the third instar (Fig. 31) consists of 22 teeth, while that of the fourth instar (Fig. 30) consists of 32 teeth.

The *hypopharynx* of the first instar (Fig. 37) lacks the ridged area, which is located caudad of the cephalic membranous area in the advanced instar. The hypopharyngeal spines increase gradually in number after each moult. The lateral spines, the movable spines and the caudal spines of the paragnatha (Pgn) increase in number from the first to the fourth instar.

IX. KEY TO THE LARVAL INSTARS OF AEDES AEGYPTI BASED ON THE HEAD STRUCTURES

1. Egg burster absent 2

1a. Egg burster present (Fig. 38, EB). Mesal hairs of labral brush simple (Figs. 5 and 9, LB). Head about 0.335 mm. in width. Preclypeus divided into two lateral parts (Fig. 5, Prc). Epipharyngeal hairs (Fig. 9, EpH). Epipharyngeal processes absent. Transverse bars (TB) do not meet mesally. Mandible with five ventral dentes and four dorsal dentes (Figs. 12 and 13, VDt and DDt). Mandibular comb (MdC) with ten bristles. Maxillary brush with nine to twelve simple hairs (Fig. 21, MxB). Maxilla with no hairs arising from palpifer (Pf). Glossa with eight tree-shaped branched bristles (Fig. 27). Paraglossa lightly pigmented, with 16 teeth and a conspicuously large disto-central tooth. (Variations in teeth number of paraglossa occur among different specimens) .....**First instar**

2. Mesal hairs of labral brush entirely pectinate or pectinate intermixed with simple hairs 3

2a. Mesal hairs of labral brush simple (Figs. 4 and 8, LB). Head about 0.703 mm. in width. Preclypeus not divided (Fig. 4, Prc). Epipharynx with spine-like hairs and simple hairs (Fig. 8, Ep). Epipharyngeal processes present (Fig. 8, EpP). Transverse bars meet mesally (TB). Mandible with four ventral dentes, and four dorsal dentes (Figs. 12 and 16, VDt and DDt). Mandibular comb with 12 bristles (MdC). Maxillary brush consists of simple and spinulated hairs (Fig. 20, MxB). Glossa with 28 to 32 pectinate hairs (Fig. 28) and each pectinate hair with at least two branches. Paraglossa pigmented and with 19 teeth (Fig. 32). (Variations in teeth number of paraglossa occur among different specimens) .....**Second instar**

3. Mesal hairs of labral brush, pectinate intermixed with simple hairs (Figs. 3 and 7, LB). Head about 0.937 mm. in width. Mandible with four dorsal dentes (Figs. 15, DDt). Mandibular comb with 14 bristles (Figs. 11 and 15, MdC). Maxillary brush large, with simple and numerous spinulated hairs

(Fig. 19, MxB). Pectinate spines at meso-caudal margin of maxilla, absent. Glossa with 32 to 36 pectinate hairs (Fig. 27), and each pectinate hair with one branch only. Paraglossa with 22 teeth (Fig. 31). (Variations in teeth number of paraglossa occur among different specimens) ..... **Third instar**

3a. Mesal hairs of labral brush entirely pectinate (Figs. 2 and 6, LB). Head about 1.004 mm. in width. Mandible with five dorsal dentes (Fig. 14, DDt). Mandibular comb with 15 bristles (Figs. 10 and 14, MdC). Maxillary brush huge, with very few simple hairs and numerous spinulated hairs (Fig. 18, MxB). Pectinate spines at the meso-caudal margin of maxilla, present (PcSp). Glossa with 48 to 52 unbranched pectinate hairs (Fig. 26). Paraglossa with 32 teeth (Fig. 30). (Variations in teeth number of paraglossa occur in different specimens) ..... **Fourth instar**

X. ACKNOWLEDGMENTS

The writer expresses his indebteness to professor WILLIAM P. HAYES, the Head of the Department of Entomology at the University of Illinois, under whose supervision this research was undertaken. Acknowledgments also due to Dr. R.F. HARWOOD for providing the eggs.

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TOXICITY OF CARBON TETRACHLORIDE-CARBON DIOXIDE MIXTURES TO *DROSOPHILA VIRILIS* STURT. MEASURED BY THE RATE OF WING-BEAT

[*Diptera* : *Drosophilidae*]

(with 6 Tables)

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CONTENTS

I. Introduction. — II. Method used. — III. Correlation between dosage of fumigant and recovery time. — IV. Toxicity of CCl_4-CO_2 mixtures to *Drosophila*. — V. Conclusion. — VI. Bibliography.

I. INTRODUCTION

A review of the literature relating to the use of carbon-dioxide in admixture with fumigants shows that moderate concentrations of this gas have a marked effect on the respiratory system of insects, and that the quantity which is required to give the maximum insecticidal effect will vary with the kind of fumigant with which it is combined.

Earlier investigations : HAZELHOFF (1926-1928) observed that the spiracular opening in insects is regulated normally by the percentage of CO_2 present in the immediate neighbourhood of the spiracles and suggested that the addition of small amounts of this gas may serve to increase the effectiveness of hydrocyanic acid gas or other respiratory insecticides. Later investigations by CAMPBELL (1932) and COTTON (1932), however, have shown that the insecticidal action of HCN is not increased by the addition of CO_2. MCGOVRAN (1932) observed that a concentration of 15% of CO_2 may increase the rate of tracheal ventilation of the grasshopper, *Orphia sulphurea* F., as much as 20 times the normal. The effect of 1% of CO_2 was

to increase the average rate about 5%. No fumigants were used in admixture with the 1%, and 15% CO_2 air mixtures. KITCHEL and HOSKINS (1935) also studied the effect of various concentrations of CO_2 on the rate of respiratory ventilation in the Hawaiian cockroach *Nyctobora noctivaga* Rehn, and concluded that all of the lower concentrations of CO_2 cause an immediate increase in the rate of ventilation and that the speed of the response is dependent upon the concentration. With 5, 10 and15% of CO_2, the maximum rates of ventilation are approximately 3, 5 and 6 times the normal rate in air. With 20 and 30% mixtures, a tremendous initial increase in ventilation is followed by an almost immediate decrease, particularly with the latter concentration. Mixtures containing 50% of CO_2 gave very variable results. Undiluted CO_2 caused an immediate decline in ventilation and no evidence of an initial acceleration was found. In summarizing, the authors state "the influence of CO_2 is twofold. It comprises an initial stimulus whose intensity varies directly with the concentration, and an anesthetic effect which becomes noticeable after a period whose duration varies inversely with the concentration."

In determining the loss of water from the larval forms of the yellow mealworm, *Tenebrio molitor* L., the webbing clothes moth, *Tineola biselliella* (Hum.), and the oriental rat flea, *Xenopsylla cheopis* (Rothsch.), MELLANBY (1934) found that he could keep the spiracles of the insects open permanently by adding 5% of CO_2 to the atmosphere. It was observed that the same effect could be produced by reducing the oxygen supply to less than 1%. WILLIS (1925) states that there may be a chemical explanation of the effects of CO_2 on insects. The breathing movements of grasshoppers, *Melanoplus differentialis* (Thos.) and *M. femurrubrum* (Deg.), may be brought about by a stimulation of the nerve ganglia in the abdominal segments, either as a result of an increase in hydrogen ion concentration of pH of the blood when CO_2 goes into solution, or by the CO_2 acting in an undissociating state. WILLIS believes that the effect is similar to that produced by this gas in stimulating the respiratory center in mammals. In discussing the mode of action of CO_2, STAHN (1928) considers three possibilities : (1) that the effective stimulus is the PH in the nerve center, (2) that the gas in the tracheal endings is the specific stimulus or (3) that the gas acts on some peripheral receptor. Most work, however, indicates that the pH in the region of the nerve center probably plays the greatest part in bringing about the stimulation of the respiratory mechanism.

COTTON and YOUNG (1929) published the first account of the use of CO_2 in combination with fumigants. The results obtained by these investigators in combining CO_2 with ethylene dichloride, methyl chloroacetate, carbon disulphide and chloropicrin indicate that a dosage of CO_2 between 165 and 330 mg. per litre would, from the standpoint of economy and efficiency, be the most satisfactory for fumigation purposes.

In a later publication, COTTON (1932) states that the quantity of CO_2 needed to give the maximum insecticidal effect varies with the kind of fumigant used. He ascertained that the maximum effect with carbon disulphide (against the confused

flour beetle) is obtained in an atmosphere containing approximately 15 pounds of CO_2 per 1000 cubic feet of space. The greatest increase in toxicity of ethylene oxide and chloropicrin was obtained with 30 and 37 pounds respectively, per 1000 cubic feet. These tests, however, were conducted under vacuum fumigation conditions, and the results obtained may not necessarily coincide with the results of experiments carried out under atmospheric pressure conditions.

JONES (1938), gave data on the toxicity of methyl formate, ethylene oxide and methyl bromide to the adults of the red flour beetle, *Tribolium castaneum* (Hbst.). Experiments were also conducted in which CO_2 in the proportions of 1, 5, 10, 20, 40, 60, 80 and 99.8% was admixed with methyl formate, ethylene oxide and methyl bromide, and evidence is presented to show that the toxicity of these fumigants may be markedly increased by the addition of certain percentages of this gas. The results obtained indicate that the stimulative effect produced by CO_2 is considerably more pronounced with methyl formate and ethylene oxide than with methyl bromide. Data are also included which show that the use of concentrations of CO_2 in excess of the quantity which is required to produce the maximum increase in insecticidal efficiency may result in a material lowering of the toxicity of the gaseous mixtures. JONES reached the conclusion that the maximum insecticidal effect of methyl formate, ethylene oxide and methyl bromide is obtained with concentrations of approximately 40, 20 and 10% of CO_2, respectively and the addition of CO_2 in excess of these percentages may either impart no further increase in toxicity to the mixture. WEBB (1945) found that carbon dioxide enhances the action of derris in *Melophagus*.

II. METHOD USED

The same method used in the previous works of the author (ABOUL-NASR, 1953-1954) has been applied in running these tests. Two flowmeters, one for recording the rate of flow of CO_2 coming from the cylinder, the other recording the rate of flow of air running through columns of liquid carbon tetrachloride, were used. In the temperature tests, the fumigation chamber was enclosed during the experiments in a thermostat regulated cell with a glass front window allowing observations to be taken. By the aid of a stroboscope the wingbeat frequency was recorded in double vibrations per second (D.V./S.).

III. CORRELATION BETWEEN DOSAGE OF CCL_4 AND RECOVERY TIME

Several tests were conducted to study the relation between the dosage of the fumigant (carbon tetrachloride) and the recovery time of the insect (*Drosophila virilis*). The standard experimental procedure was briefly as follows : A lot of about 30 individuals (males and females) was confined to the fumigation chamber. The flies used were taken from the reared stock at random with no discrimination of their

age. Continuous flows of air and air saturated with carbon tetrachloride were allowed to mix thoroughly before passing to the fumigation chamber in a uniform rate of flow.

After exposing the flies to particular concentrations of the fumigant for a fixed time, they were removed from the fumigation chamber to a clean place and put under constant close observation to record the recovery time. The recovery time of 50 percent of the treated flies was taken as an average for the group under the tested conditions.

It was noticed that there is a wide range of variation in the recovery time among different individuals. Maximum time of exposure to the effect of the fumigant in any treatment was limited by the percentage of mortality produced under the tested concentration so that it should not cause more than 50% mortality among the treated flies. Minimum time of exposure under any concentration of CCl_4 is considered as the shortest time after which no less than 50 percent of the treated flies are stupefied under the effect of the fumigant.

Before the flies were exposed to the effect of the fumigant the average rate of their wingbeat measured in double vibrations per second (D.V./S.) was recorded and then after an apparent total recovery, the rate was again recorded.

It is noticed that the wingbeat frequency of the recovered flies showed a slight but clear drop in the rate. This suggests that fumigation has an after effect upon the exposed flies which may remain for a certain period (up to 24 hours) afterwards.

TABLE I

CCl_4 conc. 0.06 g./l. (Room temperature around 25° C.)

Number of flies	Average rate before exposure in D.V./S.	Time of exposure in minutes	Recovery time (For 50%)	Average rate after recovery in D.V./S.
29	212	6	20	210
34	210	8	27	205
28	198	10	34	194
27	210	15	58	198
35	212	20	64	200

TABLE II

CCl_4 conc. 0.30 g./l. (Room temperature around 25° C.)

Number of flies	Average rate before exposure in D.V./S.	Time of exposure in minutes	Recovery time (For 50%)	Average rate after recovery in D.V./S.
22	198	3	12	190
31	212	6	25	210
34	204	8	33	195
29	199	10	52	192
28	210	15	64	185

TABLE III

CCl_4 conc. 0.66 g./l. (Room temperature around 25° C.)

Number of flies	Average rate before exposure in D.V./S.	Time of exposure	Recovery time (For 50 %)	Average rate after recovery in D.V./S.
35	212	1	12	192
31	204	3	15	190
29	210	6	28	200
30	195	8	43	182
27	212	10	56	189

The following points could be deduced from the three previous experiments:

1. — Under the low concentration of 0.06 g./l. of CCl_4 the minimum time of exposure was 6 minutes and the maximum time was 20 minutes. By increasing the concentration to 0.30 g./l. the minimum time of exposure became 3 minutes and the maximum time became 15 minutes. Under a more concentrated fumigant of 0.66 g./l. the minimum time became one minute and the maximum time became 10 minutes.

2. — Recovery time under the three different concentrations of CCl_4 is to be compared only in cases when time of exposures were the same, i.e., 6, 8, and 10 minutes. When time of exposure was 6 minutes, the stupefied insects recovered after 20 minutes, in the first case (CCl_4 conc. -0.06 g./l.), 25 minutes in the second case (CCl_4 conc. 0.30 g./l.), and 28 minutes in the third case (CCl_4 conc. 0.66 g./l.). By increasing the time of exposure to 8 minutes the recovery time became 27, 33, and 43 minutes, in the three cases respectively. When the flies were exposed to the effect of the fumigant for ten minutes the recovery time was lengthened to 34, 52, and 56 minutes, in the three cases respectively.

3. — It is quite clear that the recovery time in each treatment is correlated with the time of exposure. On the other hand, more concentration of the fumigant adds to the time of recovery.

4. — The critical period of exposure, in case of low fumigant concentration of 0.06 g./l. CCl_4 lies between 10 and 15 minutes when recovery time increases from 34 to 58 minutes. Under 0.30 g./l. of CCl_4, the critical period lies between 8 and 10 minutes when the recovery time increases from 33 to 52 minutes. By increasing the concentration of CCl_4 to 0.66 g./l. the critical period takes place between 6 and 8 minutes, since starting fumigation, as the recovery time extends from 28 to 43 minutes.

5. — Wingbeat rates decline after fumigation and the effect becomes more tangible in cases of longer exposures.

IV. TOXICITY OF CCL_4-CO_2 MIXTURES TO THE FLY

Different concentrations of CCl_4, expressed in grams per liter, were mixed with different percentages by volume of CO_2, and the gases were allowed to mix

before going to the fumigation chamber where *Drosophila* flies were kept. The treatments took place under the room temperature which was around 25° C., and fumigation was kept for 30 minutes in all cases. In each treatment, concentration of CCl_4 was constant while the percentage of CO_2 by volume was varied. The average of wingbeat rate of each group of flies was recorded before introducing the fumigant.

TABLE IV

CCl_4 conc. 0.30 g./l. and 30 minutes exposure

Number of flies	Average rate before fumigation	Percent of CO_2	Average rate during fumigation	Number of survivors	Percent of mortality
28	212	—	196	19	32.1
35	204	5	210	22	37.1
26	210	10	212	20	23.0
34	198	20	202	28	17.6
37	212	30	230	31	16.4
29	214	40	224	26	10.3
24	212	50	220	22	8.3

TABLE V

CCl_4 conc. 0.66 g./l. and 30 minutes exposure

Number of flies	Average rate before fumigation	Percent of CO_2	Average rate during fumigation	Number of survivors	Percent of mortality
28	200	—	182	17	39.2
31	212	5	218	16	48.3
28	196	10	202	17	39.2
29	210	20	220	22	24.1
28	212	30	218	22	21.3
35	210	40	232	29	17.1
32	212	50	224	27	12.6

TABLE VI

CCl_4 conc. 0.89 g./l. and 30 minutes exposure

Number of flies	Average rate before fumigation	Percent of CO_2	Average rate during fumigation	Number of survivors	Percent of mortality
35	199	—	150	10	71.4
34	212	5	200	5	85.2
33	200	10	204	10	69.0
29	204	20	210	13	55.0
26	212	30	208	18	30.7
29	206	40	200	20	31.0
36	210	50	202	27	25.0

One minute after introducing the fumigant until shortly before the flies being stupefied, the rates of wingbeat of several flies of the group were recorded and the average was estimated.

The three above experiments show the following points :

1. — Under low concentration of CCl_4 (0.30 g./l.) the addition of 5% of CO_2 increased the mortality of flies by 5% than when using CCl_4 alone. The same treatment, but with the use of stronger concentration of CCl_4 (0.66 g./l.), raised the mortality by 7.9%. Still, under more concentrated CCl_4 (0.89 g./l.) the mortality percentage was raised by 14.6%.

2. — Mixing more percentage of CO_2 to CCl_4 in the three treatments caused the mortality rate to decrease gradually, in a proper proportion to the percentage of CO_2 added. This suggests that 5% of CO_2, in the case of CCl_4, seems to be the most appropriate quantity to be added, to induce the utmost toxicity.

3. — When 10% of CO_2 was mixed with CCl_4 the drop in the rate of mortality was more severe (25%) in the case of CCl_4 high concentration than in the case of low concentration (14.1%).

4. — The wingbeat rate was affected differently by mixing CO_2 with CCl_4. As expected, the wingbeat rate declined under the effect of CCl_4 when used alone. When CO_2 was added to CCl_4 in the percentage of 5, 10, or 20, the wingbeat rate increased, in all the three treatments. By adding more percentage of CO_2, i.e. 30 40, and 50%, the increase in the rate of the wingbeat continued in the two cases of 0.30 g./l. and 0.66 g./l. concentrations of CCl_4. But with the concentration of 0.89 g./l. CCl_4, the rate of wingbeat decreased.

V. CONCLUSION

1. — The recovery time of stupefied *Drosophila* flies under the effect of fumigation with CCl_4 is correlated with the concentration used, in case time of exposure is fixed. On the other hand, the recovery time depends also on time of exposure, in case concentration of CCl_4 is the same.

2. — Mixing CCl_4 with 5% of CO_2 causes the maximum rate of mortality among the fumigated *Drosophila* flies in all the treated experiments. In case CO_2 is added in percentages over 5%, the mortality rate is decreased.

3. — Addition of different percentages of CO_2 (from 5 to 50% by volume) to CCl_4 causes increase in the rate of wingbeat during fumigation except in situations where high concentrations of CCl_4 are mixed with high percentages of CO_2.

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FURTHER STUDIES UPON THE EFFECT OF CARBON TETRACHLORIDE UPON *DROSOPHILA VIRILIS* STURT.

(*Diptera* : *Drosophilidae*)

(with 9 Tables)

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CONTENTS

I. Introduction. — II. Method used. — III. Position of wings after stupefaction by CCl_4. — IV. The effect of temperature on the toxicity of carbon tetrachloride. — V. The effect of varying temperature and CCl_4 concentration upon the wingbeat. — VI. The influence of varying temperature and CCl_4 concentration upon the stupefaction period. — VII. Conclusions. — VIII. Bibliography.

I. INTRODUCTION

In an earlier work (ABOUL-NASR, 1954) some studies on the effect of CCl_4 upon the wingbeat frequency of *Drosophila virilis* were presented. The inhibiting action of the fumigant upon the activity of the wings is clearly established. The decrease in the rate of wingbeat frequency of the fly corresponds with the increase in the concentration of the fumigant during the fumigation period. The present study deals with the effect of the fumigant upon the insect under different temperature conditions. Observations are taken concerning the position of wings during the stupefaction period and its relation to the recovery ratio among these flies. A correlation between the dosage of the fumigant and the stupefaction period is drawn.

II. METHOD USED

The same procedure used in the experiments conducted to test the effect of carbon tetrachloride upon the wing-beat frequency of Drosophila (ABOUL-NASR, 1954) has been used in these experiments.

For varying the concentrations of the fumigant needed for the tests, air was allowed to bubble slowly through columns of liquid carbon tetrachloride at room temperature and by using calibrated flowmeters, the amount of air delivered to the fumigation chamber could be measured in liters per minute. The concentration of the fumigant in grams per liter could be calculated using the equation :

$$\text{Total concentration in grams per liter} = \frac{\text{Vapour pressure}}{760} \times \frac{237}{237 + t} \times \text{Mol. Wt.}$$

The gases were allowed to mix in a spacious jar before being introduced into the fumigation chamber.

III. POSITION OF WINGS AFTER STUPEFACTION BY CCL_4

BROADBENT and BLISS (1936) drew attention to the way stupefied flies held their wings after being exposed to the toxic effect of HCN acid gas. These authors discovered that, among stupefied flies, those that held their wings in normal position, recovered earlier than those that held their wings in an upward or downward position.

Similar experiments carried out upon *Drosophila virilis*, with the use of carbon tetrachloride as the stupefying agent, confirmed these findings. A tendency of recovery from the effect of the fumigant was noted earlier among flies stupefied with their wings held in normal position. The majority of the treated flies reaching stupefaction under the toxic action of CCl_4 held their wings in an upward position, especially when higher concentrations or longer exposures to the fumigant were used. In this connection BOETTIGER (1951) has suggested that carbon tetrachloride may act differently upon the direct and indirect flight muscles.

Position of wings of stupefied flies in relation to recovery ratio

TABLE I

Test with CCl_4 conc. of 0.60 g./l. and 3 minutes exposure

Position of wings	Total number of flies	Recovered flies	Non-recovered flies	Average time for recovery
Normal	8	7	1	10' 10"
Up	12	11	1	12' 30"
Down	5	5	—	12'
Between	1	1	—	11' 55"
Total	26	24	2	

TABLE II

Test with CCl_4 conc. of 0.84 g./l. and 3 minutes exposure

Position of wings	Total number of flies	Recovered flies	Non-recovered flies	Average time for recovery
Normal	5	5	—	14'
Up	16	14	2	16 5"
Down	5	4	1	15" 15"
Between	3	3	—	15' 30"
Total	29	26	3	

TABLE III

Test with CCl_4 conc. of 0.84 g./l. and 6 minutes exposure

Position of wings	Total number of flies	Recovered flies	Non-recovered flies	Average time for recovery
Normal	6	5	1	21' 30"
Up	22	17	5	26' 50"
Down	9	3	6	20' 15"
Between	2	1	1	14' 10"
Total	39	26	13	

IV. THE EFFECT OF TEMPERATURE ON THE TOXICITY OF CARBON TETRACHLORIDE

"There can be no doubt that within a given species or organism a general relation exists between metabolic condition and susceptibility to a given narcotic. Differences in metabolic condition do not exist independently of differences in condition of the colloid substratum and whether the narcotic affects primarily the substratum or certain of the chemical reactions, the susceptibility of the organism or part of its action must differ as the conditions which determine or are associated with metabolic activity differ. In concentrations in which death occurs at times varying from a few minutes to a few hours and when complicating factors are absent, the susceptibility varies directly with the general metabolic rate, conditions which increase metabolic activity increase susceptibility and vice versa". Although the preceding statement by CHILD (1915) was not made with particular reference to insects, it does apply equally well to them. In insects, metabolic activity is distinctly influenced by environmental factors. Certain factors increase the rate of metabolism; others decrease it and automatically increase or decrease the susceptibility of insects to the action of the fumigant. Since in many cases the environmental conditions can be controlled, the extent of success of any fumigation process depends upon making use of such knowledge concerning the response of insects to these conditions.

The effects of temperature changes on the flight of different insects are confusing in their variety. With certain species, among the most spectacular alterations in rate of wingbeat are those produced by variation in air temperature, whereas in other cases the response has been found nearly independent of this factor. On the basis of information gathered from the literature at hand, the species investigated fall into three groups : (1) those in which wingbeat frequency is essentially independent of external temperature; (2) those in which temperature dependence is apparent at the extremes of the physiological range of flight, but is lacking at intermediate temperatures; and (3) those in which a positive correlation of wingbeat frequency with temperature is obvious over the entire range at which flight occurs.

In the first class, the frequency remains nearly constant over a broad temperature range, and breaks sharply to lower values when the critical limit is passed in either direction (SOTAVALTA, 1947). In case of *Schistocerca*, representing class 2, there is little or no change in the rate of wingbeat between the range of 22 and 35 °C; lower rates of frequency occur below this range and higher rates above it (WEIS-FOGH, 1951). *Drosophila* flies, being very sensitive towards change of temperature, represent type 3. According to CHADWICK and WILLIAMS (1951), the change in the rate of wingbeat of *Drosophila* does not depend only on temperature but also upon the age of the fly. It was found that the frequency of the wingbeat varies through alteration in temperature, as well as by fatigue (ABOUL-NASR, A., 1954).

Although a change of temperature does not interfere significantly with the flight components such as efficiency, stroke amplitude, and angle of attack in these flies, yet it is still obscure the way higher temperatures enable the insect to increase the rate at which it expends energy. Probably this is a manifestation of the usual acceleration of chemical reactions with rising temperature.

V. THE EFFECT OF VARYING TEMPERATURE AND CCL4 CONCENTRATION UPON THE WINGBEAT

KROGH (1941) states that, "the velocity of the catabolic reactions increase in all animals (including insects) with rising temperature up to a maximum above which the temperature has a deleterious effect upon the organism". The rate of absorption and the volatility of a fumigant as influenced by changes in temperature are factors that affect the toxicity of a given quantity of a fumigant, but the greatest factor is the change in the rate of metabolic activity of the insect itself.

In a previous work the author studied the effect of changing the temperature upon the wingbeat frequency under normal conditions. This work has proved that higher temperatures cause higher rates of wingbeat (ABOUL-NASR, 1954). Also the author studied the inhibiting action of CCl_4 upon the activity of the wings, and it was realized that such inhibiting action is positively correlated with the concentration of the fumigant during the fumigation period.

Realizing the difficulty of acquiring carbon tetrachloride at a definite concentration, with the method used, it was thought to subject *Drosophila* flies to different temperatures and different CCl_4 concentrations at the same time, to find out the way these two reversed factors will act upon the wingbeat frequency.

Experiments

Several groups of *D. virilis* flies, about 30 individuals each, were introduced into a glass chamber that had an inlet and outlet for the passing of the fumigant. The first group was subjected to CCl_4 concentration of 0.60 g./l., under a temperature of 22 °C. The concentration of the fumigant in the second group was 0.68 g./l under a temperature of 25 °C., while the concentration used for the third group was 0.84 g./l. under a temperature of 30 °C. Four readings of the rate of wingbeat of five individuals of each group of flies were recorded with the aid of the stroboscope. Two readings were taken before introducing the fumigant, and the other two were taken during its introduction. This is due to the fact that the rate of wingbeat of any individual fly is not exactly the same under standard conditions but fluctuates slightly within a narrow range. This necessitates taking double readings for each case of any individual fly. This remark is also true among individuals of the same species as the rate of wingbeat there sways within a certain range known for each species. The first reading was taken at the first instant the fly responded and the second reading one minute later.

TABLE IV. — *Rate of wingbeat with CCl_4 conc. of 0.60 g./l. and 22° C.*

Wingbeat rate before fumigation in D.V./S.		Wingbeat rate during fumigation in D.V./S.	
First reading	Second reading	First reading	Second reading
165	172	145	149
162	168	155	159
171	175	162	159
159	162	160	157
166	171	152	161

TABLE V. — *Rate of wingbeat with CCl_4 conc. of 0.68 g./l.* and *25° C.*

Wingbeat rate before fumigation in D.V./S.		Wingbeat rate during fumigation in D.V./S.	
First reading	Second reading	First reading	Second reading
212	210	172	170
220	224	185	182
212	212	175	172
215	211	179	175
199	205	162	161

TABLE VI

Rate of wingbeat with CCl_4 conc. of 0.84 g./l and 30 °C.

Wingbeat rate before fumigation in D.V. S.		Wingbeat rate during fumigation in D.V./S.	
First reading	Second reading	First reading	Second reading
245	232	165	159
239	237	159	152
250	250	162	142
249	245	149	139
240	242	142	136

After studying the wingbeat rates in the three previous treatments, some points of interest can be deducted.

1. — The difference in the wingbeat rate of the two readings of the same individual under normal conditions lies within 10 D.V./S. (except for one case reaching 13 D.V./S.), and under fumigated condition the difference lies within 20 D.V./S. But the difference in the wingbeat rate among different individuals under normal conditions lies within 15 D.V./S. and under fumigated condition lies within 30 D.V./S.

2. — The second readings of the wingbeat rate tend to increase under low temperatures and to decrease under higher temperatures in both cases of normal and fumigated conditions.

3. — As expected, the rate of wingbeat under normal conditions was greatly increased under higher temperature to the extent that raising the temperature by 8 °C. caused the rate to be nearly doubled.

4. — Raising temperature and increasing CCl_4 concentration caused the rate of wingbeat to decline in matter of very short time (one to two minutes). The degree of such decline is correlated with the factor of temperature and CCl_4 concentration. Under CCl_4 concentration of 0.60 g./l. and 22 °C., the decline did not exceed more than 23 D.V./S. Under CCl_4 concentration of 0.68 g./l. and 25 °C. the decline reached up to 44 D.V./S. Under higher temperature of 30 °C. and CCl_4 concentration of 0.84 g./l. the decline was between 73 and 106 D.V./S.

VI. THE INFLUENCE OF VARYING TEMPERATURE AND CCl_4 CONCENTRATION UPON THE STUPEFACTION PERIOD

The stupefaction period is considered as a measure for the degree of susceptibility of any insect to the fumigant used. Most of the knocked down insects recover, especially if the fumigant is stopped shortly after the stupefaction. In all cases of temperature and CCl_4 concentrations used the stupefaction periods were considered as the time passed since the fumigant filled the chamber that contained the flies until 50 percent of them succumbed. Most of the stupefied flies under the effect of CCl_4 become motionless and few of them fall on their back.

Fumigation with different concentrations of CCl_4 took place under three different temperatures : 22, 25 and 30° C. The results are recorded as follow :

The influence of varying temperature upon susceptibility of the flies to carbon tetrachloride

TABLE VII

Fumigation at temperature of 22 °C.

Number of flies	Conc. of CCl_4 in g./l.	Average time for stupefaction periods
32	0.01	21' 10"
29	0.06	16' 32"
27	0.26	14' 59"
35	0.60	10' 48"

TABLE VIII

Fumigation at temperature of 25 °C.

Number of flies	Conc. of CCl_4 in g./l.	Average time for stupefaction periods
33	0.02	10' 42"
35	0.07	8' 56"
21	0.30	8' 15"
27	0.68	6' 5"

TABLE IX

Fumigation at temperature of 30 °C.

Number of flies	Conc. of CCl_4 in g./l.	Average time for stupefaction periods
25	0.02	5' 14"
27	0.09	4' 42"
29	0.37	3' 50"
35	0.84	2' 13"

The results obtained from the three previous treatments concerning the stupefaction periods under different temperatures and CCl_4 concentrations confirm the results concerning the effect of the same factors on the wingbeat rate. Under temperature of 22 °C., the stupefaction periods range between 21' 10" and 10' 48" according to CCl_4 concentration. When fumigation took place under 25 °C., the stupefaction periods became shorter as they ranged between 10' 42" and 6' 55", according to

concentration used. By raising the temperature to 30 °C., the flies were stupefied much quicker as it took them only between 5' 14" and 2' 13" to be stupefied, according to the concentration of the fumigant.

VII. CONCLUSION

1. — The stupefied *Drosophila* flies under the effect of CCl_4 with their wings in the normal position are apt to recover more quickly than those which hold their wings in upward or downward positions.

2. — The two factors of temperature and fumigant concentration are combined to find out their effect on *Drosophila* flies from the standpoints of wingbeat frequency and stupefaction periods. It has been found that the higher the temperature and the more the concentration the bigger the decline in wingbeat rate.

3. — Under low temperature the toxicity of CCl_4 does not seem to affect the wingbeat rate in a tangible manner, especially through the first few minutes from starting fumigation. Raising the temperature and slightly increasing the fumigant concentration start to hit hard on the wingbeat rate.

4. — The stupefaction period is similarly affected by raising the temperature and by increasing the fumigant concentration. The flies succumb in a shorter time under a higher temperature and more concentration of the fumigant.

5. — The explanation of the phenomenon that the fumigant becomes more effective from the standpoints of wingbeat rate and stupefaction period can be related to two reasons. First, the fumigant under higher temperature becomes more diffusible and more volatile so that it penetrates quicker through the insect. Second, the respiration rate of the insect, under higher temperature, increases, allowing more of the toxic fumigant to be taken in.

6. — Such findings of the present study can be applied in the way fumigants are used to control insect pests. Under low temperature fumigant concentration should be increased to the level that may compensate with the slow reaction of the insect to the fumigant under such temperature. Under higher temperature concentration of the fumigant can be decreased without fear of unsuccessful reaction.

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STUDIES ON THE MORPHOLOGY AND BIOLOGY OF *APHIS MAIDIS* FITCH., IN EGYPT

[*Hemiptera-Homoptera* : *Aphididae*]

(with 26 Text-Figures)

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CONTENTS

INTRODUCTION. — HISTORICAL REVIEW. — MORPHOLOGY (apterous viviparous female; alate viviparous female; instars). — FORMATION OF ALATE INDIVIDUALS (feeding on dry and fresh food; feeding on seedlings). — BIOLOGY (method and technique; moulting, population, and longevity; number and duration of generations; reproduction; hibernation and aestivation). — EFFECT OF TEMPERATURE (fatal temperature; temperature range of activity; correlation between temperature and longevity; effect of temperature on the body length of instars). — SUMMARY. — ACKNOWLEDGMENTS. — BIBLIOGRAPHY.

INTRODUCTION

In recent years, the corn leaf aphid (*Aphis maidis* Fitch.) has spread, and sometimes its infestation caused severe damages to the crops such as maize, millet, barley and wheat.

In 1942, infestation on maize was very severe and caused great loss to its yield. The infestation reached its climax at the beginning of September when field observations proved the existence of the pest in nearly every examined field. The years, accurate field observations in different parts of Egypt proved that *Aphis maidis* was a real serious pest of maize, barley, wheat, sorghums, and gramineons weeds.

As no accurate study of *Aphis maidis* has previously been made in Egypt, the present author tried to fill the gap by studying its life-history, host-plants, and any possible means for its control in Egypt. This work has been carried out at the Entomological Section of the Ministry of Agriculture, at Giza (Egypt).

HISTORICAL REVIEW

Aphis maidis was described by FITCH in 1856, who recognized it as differing from *Aphis zeae*.

WALSH (1861) observed an aphid attacking the corn roots which, when compared with *Aphis maidis* Fitch, was found to be identical. He explained that the normal habit of this aphid is to attack first the roots of the corn plant and then, when became dry, they migrate to the stem of the ear. THOMAS (1882) seems to have accepted WALSH'S explanation, and reported the existence of *Aphis maidis* on tassels, ears, stalks and roots of Indian corn.

FORBES (1891) was induced to consider the two forms as separate species and proposed the name *Aphis maidiradicis* for the root form. He based his deduction to the fact that one form could not be bred from the other. He also gave the morphological characters which differentiate the two species.

ZEHNTNER (1901) described *Aphis adusta*, but later BASHAMBAR DAS found out that it is undoubtedly similar to *Aphis maidis* Fitch.

THEOBALD (1915) reported that many apterous and some alate females of *Aphis maidis* Fitch., sent to him by WIILLCOCKS from Egypt, were indentical with his *Aphis sorghi* described from America.

DUDGEON (1915) considered *Aphis sorghi* as responsible for local damage to corn, which causes severe damage in Sudan and Gambia.

WILLCOCKS (1925) adopted the name *Aphis maidis* for the corn aphid, and recorded *Andropogon halepensis* and *Cynodon dactylon* as host-plants for it.

HALL (1926) confirmed that *Aphis sorghi* looked very similar to *Aphis maidis*.

Thus, *Aphis adusta* Zehntner and *Aphis sorghi* Theobald are both synonyms of *Aphis maidis* Fitch.

MORPHOLOGY

Fresh specimens of *Aphis maidis* Fitch were used for its description.

Apterous viviparous female

Colour dark bluish green in winter and early spring, becoming paler and yellowish in summer and autumn. The adult (Fig. 1) become gradually darker as it grows older until it assumes an almost black colour. Head and thorax are usually dull black. Antennae six-segmented, shorter than body (Fig. 2), almost black in colour, except at the base of the third segment which is pale. Comparative lengths of antennal segments as follows : first segment larger and a little langer than the second; third segment longer than the first and the fourth; fourth and fifth segments about equal in length; sixth segment composed of a basal part and a filament, the latter being twice as long as the former. Compound eyes dark reddish brown. Proboscis (Fig. 3) black, and extended to the second coxa. Abdomen dark green,

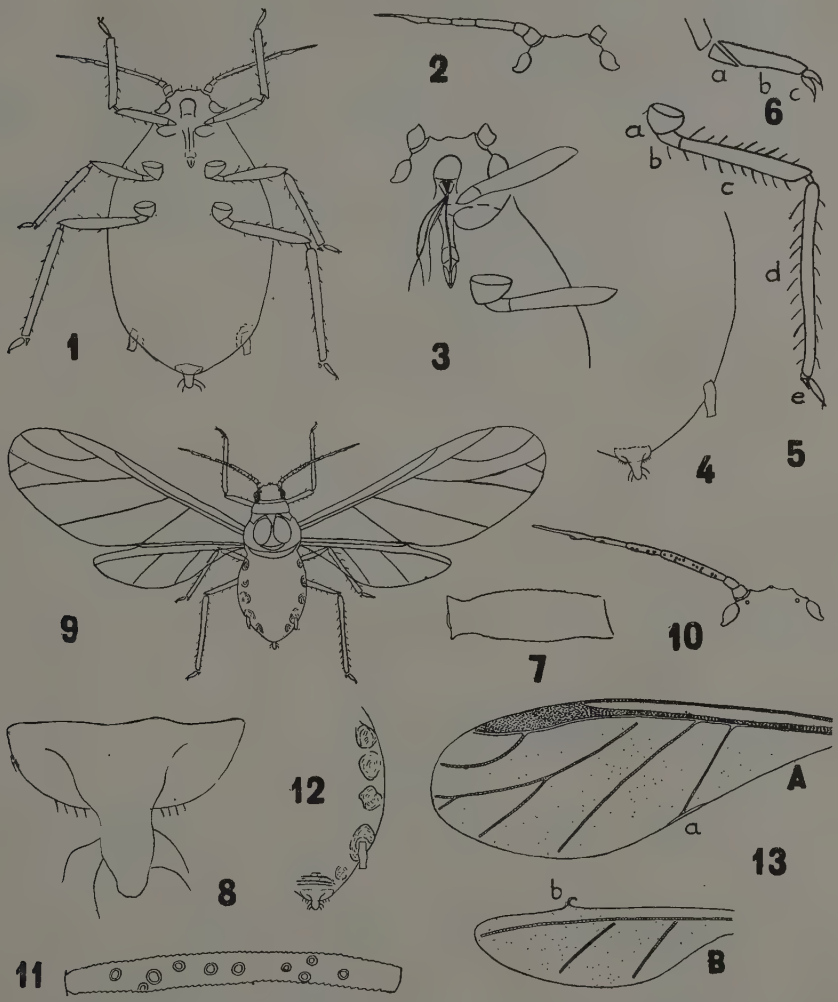


FIG. 1 : Apterous viviparous female, ventral aspect. — FIG. 2 : Head and antenna of same. — FIG. 3 : Proboscis of same. — FIG. 4: Abdomen of same, dorsal aspect. — FIG. 5: Leg of same (a, coxa; b, trochanter; c, femur; d, tibia; e, tarsus). — FIG. 6: Tarsal sub-segments or joints (a, first tarsal; b, second tarsal; c, ungues). — FIG. 7: Cornicle. — FIG. 8: Cauda and anal plate. — FIG. 9: Alate viviparous female, dorsal aspect. — FIG. 10: Head and antenna of same. — FIG. 11: Third segment of antenna of same (enlarged to shw o the shape of sensoria). — FIG. 12: Abdomen of same. — FIG. 13: Wings of same (A, fore wing; a, strong thickening; B, hind wing; b, hooklet).

elongate, oval (Fig. 4). Legs black in colour (Fig. 5), the middle of their femora pale, long, provided with hairs on femora and tibiae; tarsus double jointed, terminal joint long, carrying paired claws (Fig. 6). Cornicles (Fig. 7) black, cylindrical, slightly swollen at the middle,rather dilated at the apex, and provided with a dark spot around its base (Fig. 4). Cauda (Fig. 8) black at apex, green at base, and provided with two long curved hairs on each side. Some few fine hairs are scattered on the insect body.

Ten adults were killed in 70% alcohol, treated carefully by KOH 10%, washed in distilled water, dehydrated in alcohols and glacial acetic acid, transferred to Xylol, mounted in canada balsam on slides, and measured. The average measurements in millimetres read as follows :

Length of body, 1.83; width, 1.00; antenna I, 0.06; II, 0.05; III, 0.18; IV, 0.10; V, 0.10; VI, 0.08 (basal part) and 0.18 (filament); whole length of antenna, 0.76; length of cornicle, 0.15; length of cauda, 0.11.

Alate viviparous female

Colour pale bluish green in winter, and pale yellowish in summer. Head, thorax and abdomen markedly separated than in the apterous form (Fig. 9). Head black, bearing in addition to the compound eyes, three stemmata (Fig. 10). Antennae black, shorter than body (Fig. 10), composed of six slightly hairy segments, with comparative lengths as follows : first segment larger and longer than second, third segment longer than fourth, fourth segment a little longer than fifth. Antennal sensoria distributed on joints in circular manner (Fig. 11), and in the following numbers : 7-21 on third segment, 1-5 on fourth segment, 0-2 on fifth segment 0-1 on sixth segment at apex of basal part. Compound eyes and thorax, black. Abdomen pale bluish green, provided with five black dorsal spots on each side, the fourth spot surrounding the base of the cornicle; a dark area, composed of three more or less transverse bands (Fig. 12), is to be found near the caudal end. Legs stout and black, provided with noticeable hairs on femora and tibiae. Cornicles and cauda very similar to those of the apterous form. Wings transparent, shiny and longer than body; stigma smoky; cubitus and oblique veins dusky. Hind wings (Fig. 13 B) attached to the fore wings by hooklets (Fig. 13 B, b) on their costal border, which grip into a strong thickening (Fig. 13 A, a) on the posterior border of the fore wing(Fig. 13 A). Some fine hairs are scattered on the insect body.

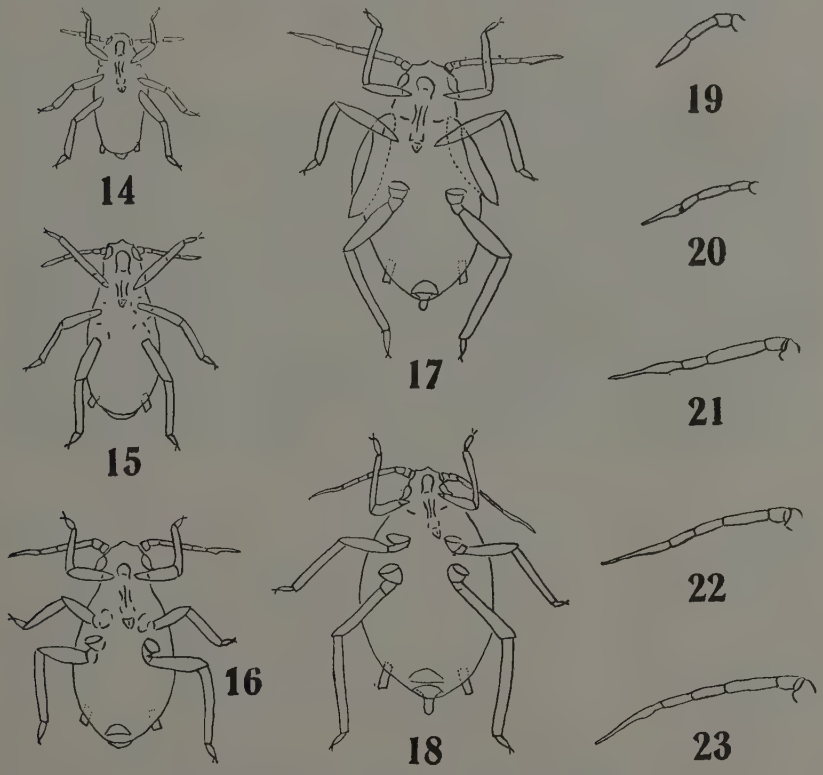
Measurements in millimetres : Length of body 1,40; width 0.55; antenna I 0.06; II, 0.05; III, 0.28; IV, 0.15; V, 0.14; VI, 0.09 (basal part) and 0.22 (filament); whole length of antenna, 0.99; length of cornicle, 0.13; length of cauda, 0.10.

The instars

The insect cast its skin four times before reaching adult stage, thus has five instars which differ in size and in some other characters.

In the first instar (Fig. 14) the insect body is rather oblong. The second instar (Fig. 15) approaches the imaginal appearance, as its body is nearly oval in shape. The third stage (Fig. 16), fourth stage (Figs. 17 and 18) and the adult are oval in shape.

Wing pads appear after the third ecdysis in the fourth instar nymphs (Fig. 17). Femora in first, second and third instars stouter than those of the fourth instar and of the adults. Antenna of first instar (Fig. 19) 4-segmented, 0.27 mm. in length; second instar (Fig. 20), 5-segmented, 0.36 mm. in length; third instar (Fig. 21) 5-segmented, 0.53 mm. in length; fourth (Fig. 22) 6-segmented, 0.65 mm. in length; fifth instar (Fig. 23), 6-segmented, 0.76 mm. in length.



FIGS. 14-16: First, second and third instars. — FIGS. 17-18: Fourth instar. — FIGS. 19-23: Antennae of first second, third, fourth and fifth instars.

FORMATION OF ALATE INDIVIDUALS

Field observations have shown that alate forms occur at all seasons of the year; they become more numerous at the end of February, March, September and

the beginning of October. They increase in number when conditions become unfavourable for the usual forms.

Among these unfavourable conditions are the following factors : (1) when barley and wheat plants start to develop their ears; (2) when plants become dry and their leaves become tougher and less juicy; (3) if host-plant is unsuitable; such as the seedlings of maize; (4) when colonies of aphids increase immensely making the breeding place crowded, and the food insufficient; (5) when honey-dew mixed with dust and black fungus cover the leaves, making them unsuitable for aphids.

Alate forms are usually detected at the beginning and at the end of infestations.

Field observations have shown that, when alate forms with or without new broods are found on a host-plant, this indicates that the insect has recently embarked and is going to live and reproduce on this host-plant. Alate forms soon disappear and the apterous forms gradually dominate, establishing a real infestation. When the whole population of the aphid colony is composed of apterous forms mingled with few alate forms and nymphs with wing pads, this means that the infestation is an old one, the host-plant becomes unfit, and the new generation of the alate form should be able to migrate to a new host-plant.

Some alate forms were isolated in a 15 cms. Petri dish provided with pieces of tender barley leaves at the beginning of February. Mothers were removed and fifty of their nymphs were allowed to reach maturity; all of these were of the apterous forms.

The above experiment was repeated at the beginning of March; 10% of the new generation was alate.

The following authors mentioned that *A. maidis* develops wings in response to special factors.

Van Breemen (1926) in Java, remarked that winged individuals of *A. maidis* occurred in all seasons of the year and that they suddenly increased in the rainy seasons. Swezey (1928) in Hawaii, noticed that the winged forms of the corn leaf aphids were produced in the cane field when the grasses went to seed. Loftin and Christenson (1934) reported that the production of winged forms, which appears to be rare in Cuba, seems to be influenced more by over crowding and climatic factors than by the form of the mothers.

The author tried to know the effect of food on aphids by breeding them on fresh and dry food, and also on seedings.

Feeding on dry and fresh food

A hundred of newly born individuals were bred in a 15 cms. Petri dish provided with pieces of tender barley leaves, changed daily in a fixed time, at the beginning of November 1948. This experiment was repeated, and food was not changed for 10 days. The following results were obtained, (1) number of alate forms increased when food was left for a longer time without being changed; (2) percentage of alates

was 12.3 when daily fresh food was given, and 81 when food was not changed for 10 days, which made it unsuitable for feeding.

Feeding on seedlings

Although grown maize plants are frequently heavily infested, *Aphis maidis* do not survive more than few days on its seedlings.

The writer tried to clear up the point of the seedlings infestation by breeding *A. maidis* on different seedlings, such as sorghums, maize, barley, wheat, and sugar-cane. Single seedlings were planted in 15 cms. diametre flower pots and were covered by lantern glass globes with organdie cloth on top, and a clean white, paper was

FIG. 24: Breeding *Aphis maidis* on seedlings planted in flower pots.

placed on surface of earth to prevent loss of the minute instars (Fig. 24). Five mature aphids were used in each trial. Every trial was repeated three times, and seedlings were 15 days old. The results obtained were as follows : (1) *Aphis maidis* thirves and reproduces readily and rapidly on barley and wheat seedlings; (2) they also do well on seedlings of sugar-cane and on the tender leaves of the more developed plants and soon they reproduce alate forms when they are supplied with tougher eaves; (3) they survive only for 3-7 days when they are fed on seedlings of maize and sorghums; (4) aphids live and reproduce quite naturally on tender leaves of the well developed plants of maize and sorghums.

BIOLOGY

Method and technique

Several efforts have been made to breed the corn aphid under laboratory conditions·

The main food which was used was barley and maize. Barley was planted in flower pots as previous described. Seedlings of maize were used in place of barley, but it proved to be unsuitable, as aphids could not survive more than three days on the seedlings. The reason is thought to be the presence of glucosides and prussic acid in the maize seedlings. The pot-breeding method proved unsuccessful owing to the following defects: (1) rise of temperature in the enclosed space; (2) high percentage of humidity; (3) the plants were nipped to keep them in space, and this seems to render leaves tougher and less juicy, causing aphids to leave them to the glass or paper surfaces; (4) aphids are usually found hidden in the central whorl of the plant, making it very difficult to examine them; (5) owing to increase of humidity, fungus spreads over the plant leaves after a period of ten days.

The writer tried to find another way for breeding aphids in captivity. Deep Petri dishes of 15 cms. diametre were tried for this purpose, using small tender pieces of plant leaves of maize during summer and of barley during autumn, winter and spring. The breeding work was once interrupted when temperature rose over 40 °C. during summer, and caused all aphids to die. The insects were examined daily and food was changed after making sure that it does not contain any aphid. When changing food, aphids were either brushed gently to give them a chance of loosening their proboscis, and then transfered to fresh food, or they were left on a small piece of old food on top of the fresh one.

Average of temperature and relative humidity was recorded daily by means of a thermograph and a hygrograph, consecutively.

Moulting, population, and longevity

Singles of newly born individuals of *Aphis maidis* were kept in Petri dishes provided with food, and were examined daily until they died. Food was changed carefully at a fixed time every day. Cast skins, number of broods, averages of temperature, humidity, and other observations were all recorded for every single insect.

Cast skins and broods were removed at the first opportunity, only mothers were allowed to stay. Fresh proceedings always started at the beginning of every month during a whole year, beginning in February 1944 and ending in January 1945.

The following points have been observed during the breeding of A. maidis under the above mentioned conditions : (1) the insect casts its skin four times till it reaches its maturity; (2) the insect begins to produce youngs after 13 days in December, 15 days in January, 9 days in March, 6 days in September and October; (3) longevity is greater in winter than in summer, reaching a maximum of 52 days in January, being 16 days in June, and 20 days in September; (4) alate forms need 1 to 3 days more than the apterous forms to start their production; (5) apterous forms produce greater number of brood than alate forms, the number varying considerably from 3 to 67 individuals for the apterous forms and from 8 to 28 for the alate forms; (6) the maximum number of brood of one apterous form was 67

individuals, and in one alate form was 28 individuals, both cases took place in October; (7) average number of brood born in a day varies between 1 to 6 individuals, but some apterous ones were able to produce 7 to 9 youngs daily for short periods in March, April, September and October; (8) apterous forms live longer than alate forms; (9) alate forms are produced mostly around January to May and October to November; (10) body length of winter individuals is greater than that of summer individuals; (11) become gradually darker in colour as they grow older until they are almost black; (12) adults become smaller in size as they advance in age, though they produce living youngs till the last day of their lives; (13) movement becomes less towards the end of the insects life.

Number and duration of generations

The experiment started by about fifty newly born individuals of *A. maidis*, and was carried out the whole year round of 1944-1945. The insects were looked after until they began to produce youngs. At the first chance, mothers were removed and youngs were only kept to continue the series of generations. It was found that *A. maidis* bred on barley and maize plant leaves alternatively had a maximum number of 45 generations in that year.

Reproduction

A. maidis reproduces parthenogenetically, producing viviparous females during all seasons of the year. No eggs are laid, no sexual reproduction takes place, and no males were ever met. Reproduction and development continue all the time, but their speed varies according to weather conditions; a whole generation may last only six days during summer and early autumn, while it may last up to twenty days during winter, and it reaches its height during early spring, late summer and early autumn.

Hibernation and aestivation

The insect is active at all seasons of the year. Neither hibernation nor aestivation were noticed, but aphids become much fewer in number during winter and mid summer, and that may be due to the unsuitable climatic factors.

EFFECT OF TEMPERATURE

It can be said that aphids, in general, withstand, to a good extent, unfavourable degrees of temperature.

Loftin and Christenson (1934) in Cuba, showed that alate aphids kept in cages were only killed when temperature was raised to 100 °F. (37.8 °C.) in the central leaf-whorls of sorghum where the aphids congregate after being driven from

the exposed parts of the plant. At the same time, WILDERMUTH (1932) in Arizona discovered that 25% of the population of aphids were able to withstand the unusual low temperature of 13 °F. (-10.6 °C.). Nevertheless, the range of temperature degrees, when aphids flourish and their activity reaches its hight, is considered to be rather narrow.

Fetal temperature

Under the facilities which were offered to the writer, it was only possible to show the effect of different temperatures from 25 °C. up to the fatal temperature. The factor of humidity and food is here ignored. Apterous and alate forms were both tried and the experiments in each case were repeated four times. Hundred adults were put in a test tube, 25 mms. diametre, covered by organdie cloth, and the tubes were left in the electric incubator with constant temperature for 24 hours. In the next morning, dead and alive insects were separated and recorded. The crowding factor should have been considered in raising the number of deaths, but as this factor is constant in all case, it has no effect on the relative fact.

The results obtained are given in the following Table :

Degree of temp.	Alate individuals			Degree of temp.	Apterous individuals		
	Alive	Dead	% of dead		Alive	Dead	% of dead
25	25	361	10	25	393	7	2
26	360	40	10	26	363	37	9
27	340	60	15	27	357	43	11
28	259	141	35	28	297	103	26
30	30	165	59	29	216	184	46
32	120	280	70	30	195	205	51
34	85	315	79	32	166	234	58.5
36	79	321	80	34	139	261	65
38	9	391	98	36	111	289	72
39	—	400	100	38	59	341	85
40	—	400	100	40	34	366	91.5
42	—	400	100	42	—	400	100
45	—	400	100	45	—	400	100

This Table shows : (1) that the fatal temperature of alate forms was 39 °C.; (2) that the fatal temperature of apterous forms was 42 °C.; (3) that the alate forms were more sensitive to higher temperature than the apterous forms; in 32 °C. death percentage in the alate form was 70 while in the apterous it was only 58.5, and in 34 °C. the percentage was 79 in the alate and 65 in the apterous.

Temperature range of activity

The writer has tried to correlate between the time of activities of the *Aphis maidis* according to field observations, with their corresponding temperature.

Generally, the insect was most active during March, April, September and the half of October in the Delta, and in February, March and October in Upper Egypt. At these months, the temperature ranges between 17 and 34 °C.

It was also found that the optimum temperature for the development of *Aphis maidis* lie between 25.3 and 28.9 °C., during which the insect reaches maturity in the shortest time (6 days). The curve in Figure 25 indicates that 270 °C. may be the most suitable temperature for the insect maturity.

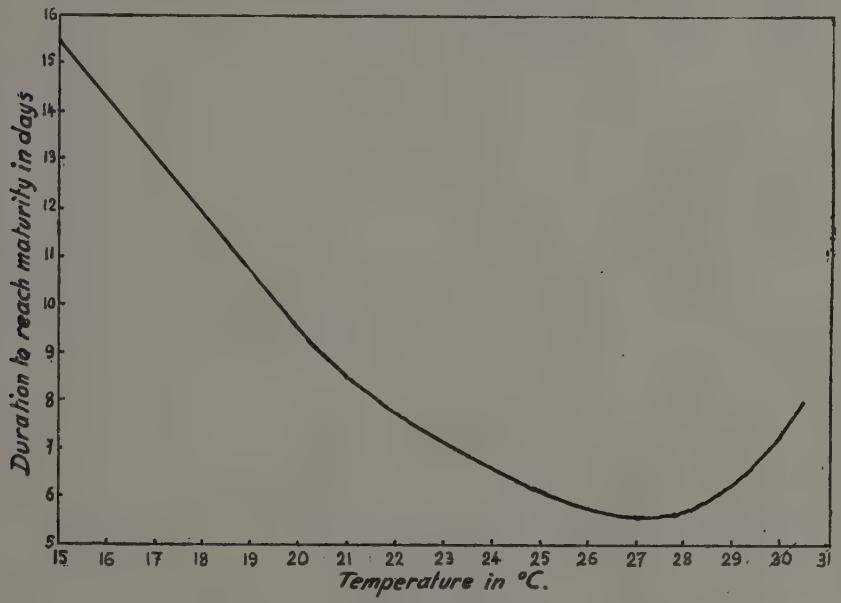


FIG. 25: Average temperature and duration of generations.

Correlation between temperature and longevity

The curve in Figure 26 shows that the insect longevity is inversely correlated with temperature.

Effect of temperature on the body length of instars

Thirteen individuals were measured. At the average temperature of 24 °C. the average body lengths were : 0.710 mm. in the first instar, 1.039 mm. in the second., 1.163 in the third, 1.343 in the fourth, and 1.356 mm. in the fifth, instar; at the average temperature of 13 °C. the average body lengths were: 0.770 mm. in the first instar, 10.073 in the second, 1.500 in the third, 1.986 in the fourth, and 2.257 mms. in the fifth instar.

Thus, it seems that the body length of the *Aphis maidis* instars is inversely correlated with temperature.

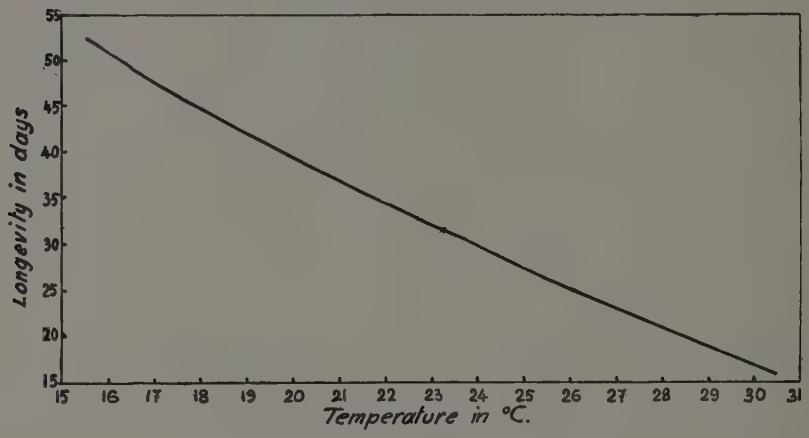


FIG. 26 : Insect longevity in correlation with temperature.

SUMMARY

The study of *Aphis maidis* Fitch has shown that the insect produces parthenogenetically giving viviparous females during all seasons of the year, no eggs are laid. no sexual reproduction takes place, no males were ever met with. The insect has five instars, and there may be 45 generations per year. No hibernation or aestivation was ever noticed.

Alate forms are developed and migrate to other host-plants when conditions become unsuitable on the first host.

Aphis maidis cannot live more than 3 to 7 days on maize and sorghums seedlings, but it can easily live on seedlings of sugar-can, barley, wheat and offshoots of sorghums.

Aphis maidis is most active in temperatures between 17 and 27 °C., but dies when the temperature surpasses 42 °C.

ACKNOWLEDGMENT

The writer wishes to thank Prof. Dr. HAMED SELEEM SOLIMAN, previously Sub-Director of the Cairo University, for his supervision, criticism and the valuable suggestions he offered during this work; to MOHAMED SOLIMAN EL-ZOHEIRY, the

former Director of the Crop-Protection Department of the Ministry of Agriculture, for his continuous encouragement and help; and to Dr. SALAH EDDIN ABOUL-NASR of the Faculty of Agriculture (Giza), who was very kind to go through the manuscript.

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STUDIES ON THE DAMAGE AND CONTROL OF *APHIS MAIDIS* FITCH., IN EGYPT

[*Hemiptera-Homoptera* : *Aphididae*]

(with 22 Text-Figures)

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CONTENTS

Geographical distribution. — Host-plants. — Field-history. — Damage (general symptoms of infestation; type of injury on barley and wheat; type of injury on cultivated gramineous plants; susceptibility of maize varieties to attack; loss in yield of maize; *Aphis maidis* as a carrier of virus diseases). — Control (mechanical and agricultural control; chemical control; biological control). — Summary. — Acknowledgment. — Bibliography.

GEOGRAPHICAL DISTRIBUTION

WILDERMUTH and WALTER (1932) stated that *Aphis maidis* Fitch is found throughout the greater part of the world between the latitudes of 40°N and 40°S. Field observations in Egypt has shown that it occurs all the year round and that its distribution is not limited. Even isolated far places, such as the Kharga and Dakhla oases, were not free from infestation. It was easily detected there on barley, wheat, and raton sorghums, in April 1949.

HOST-PLANTS

A good deal of plants act as hosts in Egypt. They are recorded hereunder, together with their local or common names, localities, and date of attack, respectively.

GRAMINEAE : *Arundo donax* (El-Ghab, iv and ix, Dokki); *Andropogon sorghum halepensis* (Sudan grass, iv-vi and viii-xi, Giza and Matana), *Andropogon sorghum saccharatum* (soccharia, iv-vi and viii-ix, Giza), *Andropogon sorghum technicus* (broom corn, iv-vi and viii-ix, Giza and Sakha), *Andropogon sorghum*

vulgare (millet, iv-vi and viii-ix, Dokki and Matana), *Avena fatua* (Zommair, ii-iv, Dokki), *Bromus arvensis* (foxtail, ii-iv, Dokki), *Cynodon dactylon* (negeel, x-xi, Dokki), *Digitaria* spec. (x-xi, Dokki), *Echinochloa colona* (abu rokab, x-xi, Dokki), *Eleusine indica* (goose grass, viii-xi, Gemmeiza), *Euchlena mexicana* (rayana, viii-xi, Giza), *Hordeum maurinum* (wild barley, ii-iii, Dokki), *Hordeum vulgare* (barley, rare in xii, common from, middle of i to iv, Dokki), *Panicum colonum* (abu rokba'i, v-ii and x-xii, Dokki), *Panicum stagninum* (v-vii, Dokki), *Pennisetum glaucum* (wild millet, x-xi, Giza and Sakha), *Setaria* spec. x-xi, Dokki), *Triticum* spp. (wheat, 15. i-iv, Dokhi), *Zea mays* (maize, v-vi and 15. viii-xi, all over Egypt), *Zea mays everta* (fishar, ix-xi, Dokki), *Zea mays saccharata* (sweet maize, ix-xi, Dokki)

POLYGONACEAE : *Polygonum* spec. (x-xi, Dokki).

Although KUNKEL (1922) in Hawaii, CHARDON and VEVE (1923) in Porto-Rico, VAN BREEMEN (1926) in Java, HANSFORD and MURRAY (1926) in Jamaica, WOLCOTT (1928) in Peru, and INGRAM, HALEY and CHARPENTIER (1939) recorded sugar-cane as a host-plant to *Aphis maidis* Fitch., this insect could not be found in Egypt on seedlings and old sugar-cane plants, except once when some alate forms occured on sugar-cane seedlings which were quite near to infested barley and wheat fields. Also WILLOCKS (1925) noticed that no aphids occur on sugar-cane in Egypt.

FIELD-HISTORY

The behaviour and hosts of *Aphis maidis* has been carefully watched in the field troughout the year. Figure 1 shows the movement of *Aphis maidis* from cultivated crops to weeds and vice-versa.

Aphis maidis is found on the weeds (*Panicum colonum*, *Digitaria* spec., *Cynodon dactylon*, *Setaria* spec., and *Polygonum* spec.) from which it migrates to early grown barley at the end of December and the beginning of January, in small and unnoticeable numbers. A little later, in the middle of January, it migrates to wheat where the infestation continues until March or April. When barley and wheat finish earing, the insects retire again to gramineous weeds (*Panicum colonum*, *Avena fatua*, *Hordeum maurinum*, *Sorghum virgatum*, *Bromus arvensis*, and *Arundo donax*) or they may migrate to young cane plants for a short while, if these are available at that time.

During May and the first week of June *Aphis maidis* attack sorghums hearts. When these plants reach the heading stage, the insects migrate to either the summer maize at the second part of May, if this is found, or to gramineous weeds growing at the sides of the canals.

Panicum colonum is the most favoured host-plant for *Aphis maidis* during June and July. The aphids attack mostly the inner surface of the leaves, hearts, sheaths, and the upper parts of the ears. It is also found on *Panicum stagninum*.

From the last week of August until the last week of october, and sometimes to the end of November, *Aphis maidis* attacks heavily the Nili maize and sorghums, and it is also found on gramineous weeds.

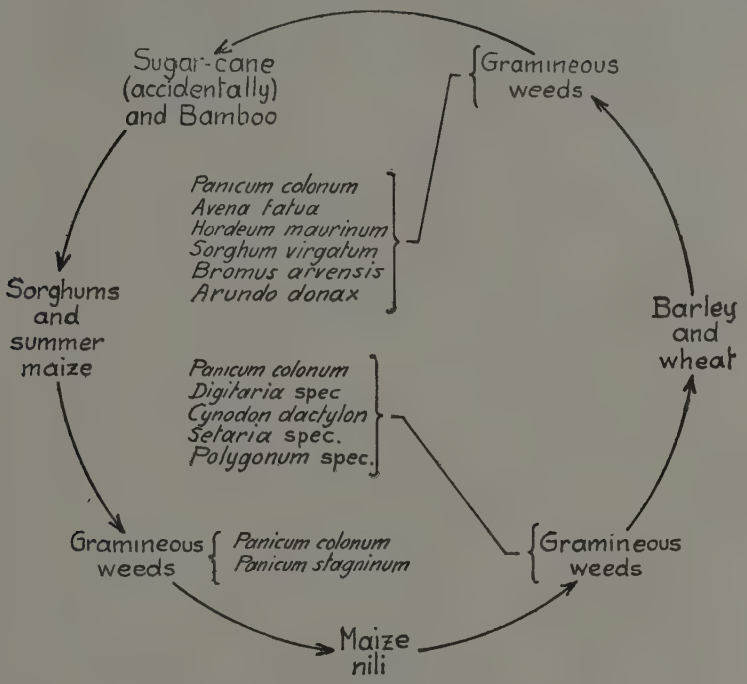

FIG. 1 : Movement of *Aphis maidis* from cultivated crops to weeds, and vice-versa.

Time of infestation on different crops varies according to locality and climatic factors. Infestation on barley and wheat first appear in Upper Egypt, then in Middle Egypt, and lastly it reaches the Delta. The contrary happens in the case of the Nili maize infestation, as this starts first in the Delta, a little later in Middle Egypt, and ends in Upper Egypt. It is to be noted that summer maize is cultivated in March and April, while Nili maize is usually grown from July to August.

Times of severe infestations on barley, wheat, sorghums and maize in the different parts of Egypt can be summarized as follows.

From February to April in Delta, from the second half of January to April in Middle Egypt, and from December to March in Upper Egypt, on barley and wheat plants.

From April to June and from the second half of August to November in Delta and Middle Egypt, and from September to December in Upper Egypt, on sorghum plants.

From the second half of August in the north, from the first half of September to the first half of October on tassels, and during October and November on cobs, in Delta; from the second half of September to October on tassels, and in October and November on cobs, in Middle Egypt; from first half of October on tassels, and during October and November on cobs, in Upper Egypt, on maize plants.

Generally, it can be said that there are two climaxes for *Aphis maidis* attack: the first occurs around the end of winter and the beginning of spring on barley and wheat plants, and the second around the end of summer and the beginning of autumn on maize.

The degree of infestation in relation to mouths is clearly shown by the curve in Figure 2.

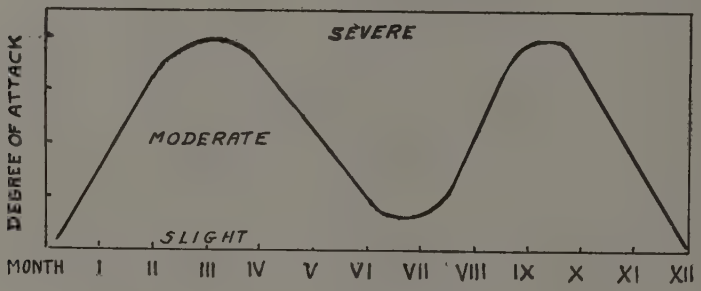

FIG. 2 : Infestation curve.

DAMAGE

Aphis maidis causes the following damages to the infested plants : (1) it sucks the sap of the plant leaves causing decrease of the plant vitality; (2) it sucks the plant sap causing the delay or even the stoppage of the formation of tassels and ears of barley and wheat, and prevents or reduces the production of pollen; (3) it sucks the sap of maize ear silks causing them to get dry, prevent fertilisation and produce empty or poorly filled ears; (4) the insects produce a copious flow of honey-dew which sticks on the leaves and catches dust, preventing photosynthesis and reducing the quantity of starch produced by the leaves, thus causing a reduction of the crop yield; (5) black fungus grows on plants attacked causing extra damage to these plants; (6) the insect transmit diseases from infected plants to the healthy ones.

General symptoms of infestation

Infested plants of barley and wheat become dwarf with curled leaves, droop, turn yellow, dry, and at the end they may die; honey-dew turn them wet and dirty as they get covered with dust; dry honey-dew on the infested parts give them a shiny

and glossy appearance; small white cast skins are found on the infested parts of the plant; growth of black fungus occur on the honey-dew; occurrence on the infested plants of predaceous insects that feed on aphids, especially Coccinellids (Coleoptera), Chrysopid larvae (Neuroptera), and Syrphid larvae (Diptera); occurrence of other scavenger insects, such as ants, flies and beetles that feed on decaying organic matters.

Type of injury on barley and wheat

Aphis maidis starts infesting barley and wheat plants when these are about 25 cms. high, at the end of December and during January. It first appears on barley and soon on wheat, reaching its climax of infestation between mid-February and the end of March. As the time for earing approaches, the insects develop wings and prepare to leave the original host to go to late cultivated plants having, tender leaves, or to other host-plants.

Aggregations of aphids prefer to attack the whorl of tender leaves of the heart, the inner basal part of other leaves, their back, and their sheaths. Ears are generally free from aphids.

Infestations mostly take place on the upper third of the plant, and only small numbers of aphids may occur on the basal part of the leaves and under sheaths.

It was observed that early severe infestations delay or may stop earing altogether. Sometimes, infestation may prevent plants to reach maturity.

By sucking the sap of the plants, their colour changes into yellowish-green or yellow, until they dry, and finally die.

Field observations showed that infestations generally occur in some parts of the field, but sometimes they spread all over the whole areas.

It was also noticed that the amount of *Aphis maidis* on wheat was less than on barley, and on the former they were accompanied with other kinds of aphids (*Toxoptera graminum* Rond., occured in great numbers).

An examination of the experiments carried by the Plant-Breeding Section of the Ministry of Agriculture at Giza in order to find out the susceptibility of the different varieties of barley and wheat to *Aphis maidis*, allowed the following conclusions : (1) barley was more strongly attacked than wheat; (2) baladi wheat 116 was more liable to be infested than the Hindi D; (3) lenta barley (2 rowed) was more severely infested than the Baladi 16 (6 rowed) variety; (4) susceptibility to infestation on barley varied very much, from very severe to very slight infestation on the different kinds of barley; Habashi, German, and Palastine 3 were very severely infested; Greece, Faculty 2, and Syrian were severely infested; Hungari and Turkish were moderately infested; English and Palastine 10 were slightly infested; Nabawi, Hirrawi, Baladi 16, Higazi, Russian and Burg-El-Arab were very slightly infested; Sina and Palastine 34 were rarely infested.

Type of injury on cultivated gramineous plants

Sorghums are generally cultivated during March and April, but sometimes they may be late until July. Field observations showed that sorghums are favourite food-plants for *A. maidis*. Late cultivated plants are generally exposed to severe infestations, if they are still tender prior to September. All kinds of sorghums are attacked, but degree of injury depends on variety and climatic conditions. The attack starts when the plants are about one metre high and 45 days old.

Aphids suck the sap of the tender leaves of the heart until the time for heading out approaches, when the winged individuals suddenly increase; then the ears appear free from aphids. Sometimes, when the leaves of the heart become yellow, they droop and die, causing the plants to shoot side late growths, exposed to be re-infested by aphids and other insects.

Sometimes, when infestation is very severe, the newly formed heads are also attacked by aphids, which suck the sap of flowers and seeds, producing poorly filled heads with small atrophied seeds.

If infestation continues on the heads, sooty kinds of fungi grow on the honey-dew of the insects, causing the heads to appear dirty black.

Severe infestations may spoil the growing tip of the plant and stop earing.

Reddish discolorations are generally associated with *Aphis maidis* infestation on sorghums, either on floral axes or leaves under the ear. McCollock (1921) in Kansas, stated that these colours are due to bacterial infections.

Off-shoots and small ratoon plants are severely infested in all stages, both of the two kinds grow late.

Field observations showed that all kinds of sorghums are liable to be infested, but susceptibility of infestation varies according to the different varieties of sorghums

The sorghum plants can be arranged according to their susceptibility as follows : (1) *Sorghum vulgare* (millet); (2) *Sorghum technicus* (broom corn); (3) *Sorghum halepensis* (Sudan grass); (4) *Pennisetum glaucum* (wild millet); and (5) *Euchlaena mexicana* (goose grass).

The susceptibility of different varieties of millet to *Aphis maidis* examined at the Plant-Breeding Section (Giza), runs as follows : (1) all varieties of millet were liable to be infested; (2) degree of infestation varied in the different varieties; (3) infestation occurred in the heart of the non-earing plants and in the hearts of the off-shoots growing beside the plants, and scarcely on the heads; (4) the plants which were still tender, juicy and non-earing prior to September, were more infested.

Maize

Maize plants cultivated in both summer and Nili (i.e. March and July, respectively) periods are infested with *Aphis maidis*, but, generally, the Nili crop is more severely infested.

Field observations showed that the infestation begins prior to the appearance of the tassels. Severe infestations often occur in the tassels, when they are about to expand, the lower part of the tassels being the most favoured by aphids.

Also the cob husks and silks the upper tender leaves, the inner side of the leaf sheaths (especially the upper part of the sheaths), the inner side of the bracts of the panicle and the panicle itself, are prefered by the aphids.

The entire tassel may be so heavily infested that it fails to undergo its function, and shedding of pollen may be greatly reduced or entirely stopped.

Honey-dew sticks the tassel branches to the flowers, and prevents them from fulfilling their function. It also attracts other insects and forms a suitable medium for fungi.

Leaves of maize, generally, show little deformation; but sometimes, when severely infested, they may become yellow, droop and die.

When the aphids attack the cobs, they suck the silks sap, and the honey-dew sticks them together, spoiling them and preventing fertilisation, with the result of small and poorly developed ears.

When the aphids attack the cob-husks, only three or four of the outer layers are infested, while the inners are always free from aphids.

Sometimes, aphids attack cobs when their seeds are still fresh and tender, especially when they are laid bare by birds, suck their sap and produce poorly developed ears and small seeds.

After a period of 2-3 weeks from the time of the infested tassels expansion, various kinds of fungi grow on the honey-dew, and the tassels become black. This is followed by the appearance of winged aphids which soon migrate to other suitable plants.

Alate forms are usually seen at that time in great numbers among the whole aphid population.

Susceptibility of maize varieties to attack

Varieties of maize examined are divided into two groups. To the first group belong the American Badri, Giza Baladi, and Nab-el-Gamal; the second comprise the Sabini, Succharia, and Fishar.

Accurate field observations were carried out at Gemmeiza and Sids Farms in 1948, on some varieties of maize in order to investigate the susceptibility of these varieties to *Aphis maidis*.

All these varieties were found to be attacked by *Aphis maidis*. The period of earing in the first group was longer and the ears kept tender and juicy for a longer time than in the second group. Tassels in the second group died soon. Infestation in the firist group was quite obvious and continued for rather a long time.

The second group varieties were first severely infested, but soon infestation came to an end, and their tassels dried early. Tassels of Sabini developed faster, dried earlier and were slightly infested. Succharia was the first in infestation, then

Fishar followed, and Sabini was the last. Giza Baladi infestation was slightly less than in other varieties of the first group. Its tassels dried quicker.

The varieties can thus be classified according to their degree of infestation, as follows : (1) Nab El-Gamal, (2) American Badri, (3) Succharia, (4) Fishar, (5) Giza Baladi, and (6) Sabini.

Loss in yield of maize

Several fields of maize at Menufia and Caliubia Provinces were examined in September, with the idea of investigating the loss in yield of maize by comparing the average number of seeds in healthy cobs with those of severely infested cobs of the same variety and field. This preliminary examination has shown a reduction of 5 to 10% in the number of seeds of the infested cobs.

The loss in yield by weight, was measured in the course of a spraying experiment which was carried out at the Matana Farm, in 1943. In this connection, plots sprayed with nicotine sulphate 0.15% in soap emulsion were considered to be aphid-free, and so their yield was compared with other infested plots which were left as control. It was found : (1) that sprayed symbols gave a higher yield than the control, (2) that increase in yield varied between 1.08 and 12.3% with a total average of 7.2%.

Aphis maidis as a carrier of virus diseases

Although on sugar-cane, KUNKEL (1922) in Hawaii, BRANDES (1920) and WILBRINK (1922) in Java, HANSFORD and MURRAY (1926) in Jamaica, WOLCOTT (1928) in Peru, and SWEZEY (1926) in Hawaii, mentioned that *Aphis maidis* was the chief vector of mosaic to sugar-cane, the writer had the chance, in 1948, to examine at Kom-Ombo Farms (Upper-Egypt) different samples of sugar-cane lacking chlorophyll in their leaves. All were 2-3 months old and 30 to 40 cms. in height. It was found that the two kinds of American No. 105 and No. 2878 were severely infected, while No. 281 showed great resistance, and moderately contaminated. It was also noticed that the newly cultivated plants were less infected than the ratooned plants.

Insects such as thrips (Thysanoptera), jassids (Hemiptera-Homoptera), and *Pseudococcus sacchari* (Homoptera-Coccidae), were found on the cane plants. Some accidental alate forms of *Aphis maidis* occurred on the new growth among other insects, in February 1949. The source was the neighbouring infested barley and wheat.

It is the writers opinion that this case represents a virus disease, and that alate individuals of *Aphis maidis* and of jassids are responsible for its transmission to sugar-cane in Egypt, in accordance with the investigations carried by SWEZEY (1926) in Hawaii, CHARDON (1922) in Porto-Rico, and STOREY (1925) in Natal.

On maize and sorghums

BRANDES (1920) proved experimentally that the mosaic of maize is transmitted

by *Aphis maidis*, and that the disease was identical with that of sugar-cane and sorghum mosaic.

COTTRELL-DORMER (1926) in Queensland, mentioned that maize and sorghums serve as hosts for *Aphis maidis*, and for the mosaic disease as well, and that they should not be grown in the vicinity of sugar-cane, to prevent the spread of this disease.

The present writer observed mosaic symptoms on some plants of maize and sorghums at the Plant-Breeding Section fields (Giza), in September 1949, but these were very scarce and were not easily detected.

On onion

The experiments of DRAKE, HARRIS and TATE (1932), and HUNDERSON (1935), showed that *Aphis rumicis* L. and *Aphis maidis* Fitch. were the real carriers of the yellow dwarf virus disease of onions which they transmit from the infested to the healthy plants. The writer examined many fields of onion at Kom-Ombo, severely infected by the yellow-dwarf disease, but no aphids of any kind were detected on the plants.

On the other hand, the field of onion was surrounded by lands under barley and wheat, which were severely attacked by *Aphis maidis*.

Therefore, the writer believes that *Aphis maidis* is not responsible for the transmission of that virus disease of onion in Egypt.

CONTROL

Mechanical and agricultural

Some experiments were carried at the Ministry of Agriculture farms to find out whether it is possible to reduce aphid infestation by the following methods.

Effect of sowing dates on maize

Experiments carried out at Gemmeiza Farm (1942) in the Delta, showed that degree of attack was rare in June 15th., moderate in 1st. July, severe in July 15th., slight in 1st. August, and very slight in August 15th., sowing dates of Giza Baladi maize plants, while it was rare, severe, slight, and very slight, respectively, in the same dates on American Badri maize plants.

At Sids Farm (1945) in Middle Egypt, the attack was slight in 1st. August, moderate in August 15th., and very slight in 1st. September, sowing dates of Giza Baladi. It was moderate in 1st and 15th August, while it was slight in 1st September, sowing dates of American Badri. It was slight in 1st August, moderate in 15th August, and slight in 1st September, sowing dates of millet Giza 25.

At Matana Farm (1943) in Upper Egypt, the attack was severe in 1st and 15th August, sowing dates of Giza Baladi and American Badri. It was slight in 1st and 15th July, while it was moderate in 1st August, and severe in 15th August, sowing dates of millet Giza 25.

Result of experiments obtained by the Experimental Section of Ministry of Agriculture showed that the suitable sowing dates, to give best yield in Egypt, run from 1st to 15th July in the Delta, from 15th to 30th July in Middle Egypt, and from 1st to 15th August in Upper Egypt, for maize; from mid-April until the end of May for the summer crop, and from the second part of July for the Nili crop of millet Giza 25.

If these results are compared, it can be esily deduce that : (1) severe attack of aphids coincides with the best sowing date of maize plants; (2) although it was obvious that early planted maize was less attacked by aphids, yet early cultivation of maize does not produce good yield.

Effect of sowing dates on barley

The writer examined an experiment of sowing barley at three different times (18th and 25th November, and 2nd December, 1948) at the Plant-Breeding Section, (Giza), in March 1949. It was found that late cultivated plants of barley were attacked by *Aphis maidis*, that ears were generally free from aphids, and that the degree of attack varies according to the different varieties of barley.

Effect of sowing dates on millet Giza 25

An experiment of sowing millet Giza 25 conducted by the Plant-Breeding Section (Giza) at three different dates (23rd and 30th June, and 7th July, 1949), showed that late cultivated plants of millet Giza 25 were more severely infested than those cultivat ed earlier in the season.

Cutting infested tassels of maize plants

As mentioned before, the maize tassel is the most favoured site for aphids attack, and so, it was suggested that cutting of these tassels at different times and different quantities may give a good means of aphid control. This method was carried out in two places, with different cutting percentages on American Badri maize plants, at Matana Farm (1943) and Sids Farm (1945).

Comparing the yield of the treated area at Matana Farm, with an average cut of about 24%, the average yield was 6.63 ardabs per feddan, which over-runs for 1.08 ardab that of the near by average yield of the control field, which was 5.55 Ardabs per feddan. At Sids Farm, with an average cut of 37%, the yield was 15.89 ardabs per feddan, and 17.40 ardabs per feddan for the control area.

Therefore, it can be deduced that cutting of severely infested tassels of maize plants during the first week following tassel unfolding, could be considered as a suitable means for *Aphis maidis* control; this cut causes infestation to become slighter, as the remaining aphids can be checked biologically giving them no chance to attack the ear-silks, and that it should not exceed, by any means, a 25-30% of the whole numbers of tassels.

Chemical control

Different spraying treatments were carried out in 1943, on maize plants, at Matana Farm, to measure the effect of spraying on aphids and crop, compared with cost of treatment.

Spraying

Several difficulties were encountered when spraying with nicotine sulphate 1-1.5‰ in soap emulsion : (1) maize plants were about 3 metres high, and therefore it was difficult to pass through the field without causing injury to the plants; moreover, the operation proved to be very difficult; (2) the sharp edges of the leaves added more trouble to the workers; (3) the high ends of the tall plant tassel were left without spraying owing to the shortness of the spraying pumpt-cane; (4) splashes from the spraying solution caused irritation to the worker's eyes and repeated interruptions of the operation; (5) Knapsack sprayers proved to be the only suitable type for this kind of work which nevertheless, was progressing slowly owing to the previously stated difficulties; (6) the operation was comparatively slow, and to think of applying the spraying method on a large scale is quite impracticable; one worker could not possibly spray more than 4 kirats (about 700 square metres) per day.

Treated maize plants were examined for two days after the operation with the following results : (1) all insects, which were reached by the spray solution, were killed; (2) short plants two metres high and with exposed tassels, showed 98% kill; (3) tall plants three metres high, or those with incompletely developed tassels, had 30-70% kill; (4) plants which had aphids hidden under leaf sheaths or on unfolded tassels, had only 10% kill; (5) the average kill was 80%; (6) unaffected aphids were later attacked by their natural enemies which traced them eagerly and destroyed a good number of them within the first week which followed the treatment.

Cost of materials

The spraying experiments showed that cost of materials needed for spraying the whole plant of maize with 0.1% solution of nicotine sulphate in soap emulsion is about 250 piastres for one feddan (acre). To this amount, another 100 piastres should be added as hand labour for 10 workers, raining the total cost to 350 piastres for one feddan. If 0.15% solution is used, the treatment of one feddan will cost 436 piastres.

Cost of materials used for spraying (0.1% nicotine sulphate) the top third of maize plants of one feddan is 178 piastres. Again, by adding 100 piastres more as hand labour, the whole cost comes to 278 piastres for one feddan. If 0.15% solution is to be used, cost of treatment amounts to 340 piastres for one feddan. Cost of materials are considered here, according to the price at the date of performing the treatment : 48 piastres for one lb. (390 ccms.) of nicotine sulphate, black leaf 40, and 4 piastres for one lb. (450 gms.) of soft soap. 1400 litres of solution were used for spraying the whole plants, and 1000 litres were used for spraying the top third of maize plants of one feddan.

Although spraying aphids with nicotine sulphate solution in soap emulsion is beneficial, it is very difficult to apply, and if the cost of the treatment is compared with the price of the lost crop, which was 0.32 ardab in the control, it becomes clear that the treatment is not economical.

Biological control

Aphis maidis Fitch. is checked in nature by a great number of natural enemies living among the aphid colonies. These are either predators or parasites. Coccinellids and Syrphid larvae are the most important among aphid predators, while several minute wasps act as parasites on them.

Predators

HEMIPTERA : The nymphs and adults of *Orius albidipennis* Reut. (Fig. 3) and *Orius laevigatus* Fieb. (Fig. 4) feed on young nymphs of *Aphis maidis*. The appetite test in September, 1949 (26 °C.) was that these Anthocorids are able to destroy daily from 11 to 30, with an average of 21 nymphs of *Aphis maidis*.

NEUROPTERA : The larva of *Chrysopa vulgaris* Schn. (Chrysopidae) lives on *Aphis maidis*. The appetite test in September, 1949 (26 °C.) showed that the larva of *Chrysopa* is able to destroy daily from 11 to 30 of *Aphis maidis*. The larvae appeared mostly during the end of September, the beginning of October and again during March.

COLEOPTERA : Coccinellid beetles are commonly seen feeding on *Aphis maidis*, while they are in the larval or adult stages. Their eggs are laid in batches among aphid colonies.

The larva of *Coccinella undecimpunctata* L. is campodeiform, almost hairless, black spotted with yellow and white colours, becoming paler in colour prior to pupation. The larva of *Scymnus* assumes a mealy-bug appearance owing to the presence of white flocculent secretion covering its body.

Coccinellid pupae are usually seen attached to leaf surfaces, to twigs of plants or in any other suitable place near the aphid colonies.

The following Coccinellids were actually collected and observed preying upon *Aphis maidis* in the larval and adult forms : (*Coccinella undecimpunctata* L., *Scymnus syriacus* Mars. (Fig. 6), *Scymnus interruptus* Goeze (Fig. 5), *Cydonia* (*Chilomenes*) *vicina nilotica* Muls. (Fig. 7), *Cydonia* (*Chilomenes*) *vicina subsignata* Pic (Fig. 8) and *Pharoscymnus varius* Kirsch.

Larvae and adults of *Coccinella undecimpunctata* and *Scymnus*. spp. were the most numerous, while *Cydonia* and *Pharoscymnus* were scarcer.

Rough counting of Coccinellids on one severely infested tassel of maize plant with *Aphis maidis*, about the end of September, gave 25 to 105 larvae, pupae, and adults of *Coccinella undecimpunctata*, and 20 to 80 larvae and adults of *Scymnus* spp.

Great numbers of aphids are consumed daily by both kinds of larvae, but adults, perhaps, are more voracious.

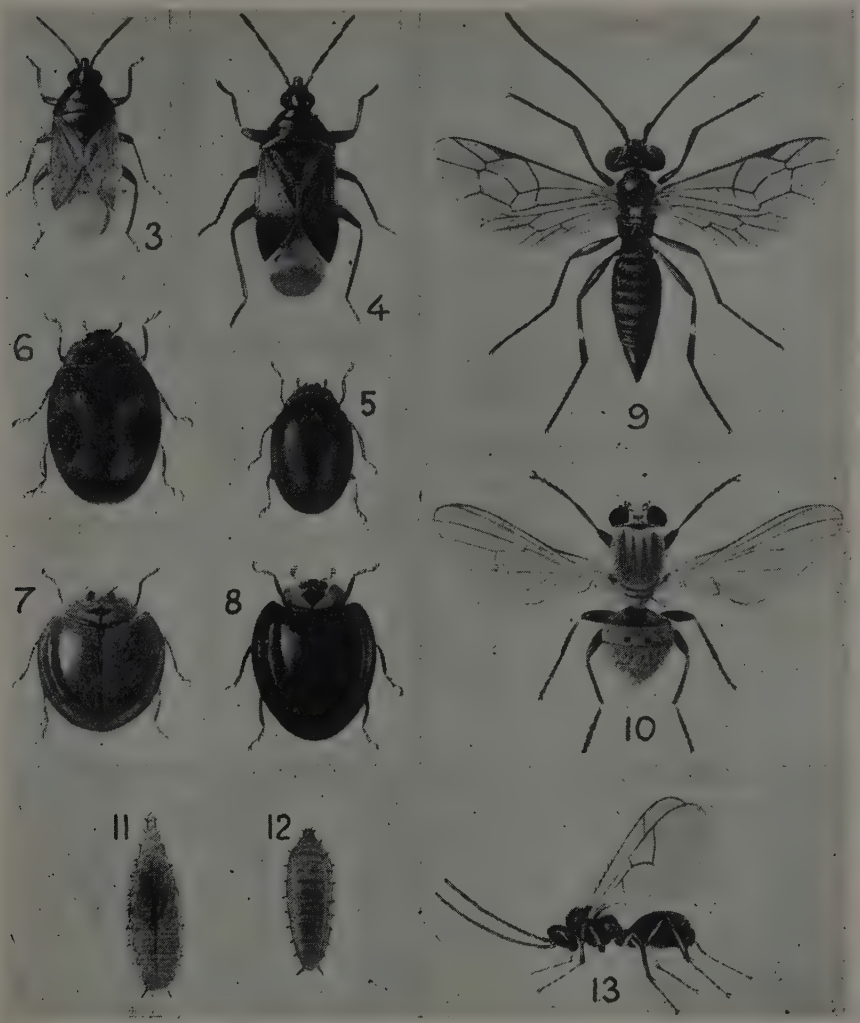

FIG. 3 : *Orius albidipennis* Reut. — FIG. 4 : *Orius laevigatus* Fieb. — FIG. 5 : *Scymnus interruptus* Goeze. — FIG. 6 : *Scymnus syriacus* Mars. — FIG. 7 : *Cydonia* (*Chilomenes*) *vicina nilotica* Muls. — FIG. 8 : *Cydonia* (*Chilomenes*) *vicina subsignata* Pic. — FIG. 9 : *Bassus laetatorius* F. — FIG. 10 : *Leucopis puncticornis aphidivora*. — FIG. 11 : Larva of *Leucopis puncticornis aphid-ivora*. — FIG. 12 : Pupa of *Leucopis puncticornis aphidivora*. — FIG. 13 : *Charips* sp., male. — (All Figures enlarged).

Some larvae and adults of *Coccinella undecimpunctata* were provided with enough *Aphis maidis* for three successive days to estimate the average number

consumed by each, in September, 1949 (26 °C.). The number of *Aphis maidis* consumed daily by a single larva of *Coccinella undecimpunctata* ranged between 10 to 22, with an average of 17, and in the case of the adult, it ranged between 8 to 69, with an average of 34.

Field observations showed that Coccinellids were abundant and prayed upon *Aphis maidis* in March and April on barley, and in October on maize plants.

Diptera : *Syrphus corollae* F., *Xanthogramma aegyptium* Wied., *Sphaerophoria flavicauda* Zett., and *Paragus aegyptius* Macq., all of which belong to the Syrphidae, prey on *Aphis maidis* in their larval stage. They are very active and numerous from mid-February to end of March on barley, and during September up to mid-October on maize. While breeding in the laboratory, an Ichneumonid parasitic wasp, *Bassus laetatorius* F. (Fig. 9) emerged from larvae of *Xanthogramma* and *Sphaerophoria*.

Some larvae of *Syrphus corollae* F. and of *Xanthogramma aegyptium* Wied., were kept singly in tubes provided with 100 individuals of *Aphis maidis*, in October 1949 (24 °C.). The material was examined after 24 hours to estimate the number of aphids consumed. A single larva of *Syrphus corollae* F. consumed between 7 to 31 *Aphis maidis* with an average of 18, and *Xanthogramma aegyptium* devored between 22 to 52 with an average of 35.

The larvae of the Ochthiphilid *Leucopis puncticornis aphidivora* (Fig. 10) prey upon *Aphis maidis*. In September 1949, *Leucopis* larvae (Fig. 11) were noticed to feed on *Aphis maidis* only in small numbers, while at the same time the were more numerous on cotton plants, preying upon *Aphis gossypii* Glov. During laboratory breedings, three males of a minute Cynipid wasp, *Charips* sp. (Fig. 13) emerged from *Leucopis* pupae (Fig. 12).

Small reddish maggots (Fig. 14) of an unidentified species of Cecidomyid (Fig. 15) were noticed feeding on small nymphs of *Aphis maidis* infesting barley in March, and tassels of maize in September. These maggots occured usually in small numbers among colonies of *Aphis maidis*, but were more numerous among colonies of *Aphis gossypii* Glov.

Parasites

All the parasites emerged from *Aphis maidis* belong to the Hymenoptera. They were identified by Dr. Ch. Ferrière of Geneva, to whom the author is much indebted.

The Encyrtid *Aphidencyrtus aphidivorus* Mayer (Fig. 16) is a very minute black species. Parasitised aphids become dark green, with a conspicuous black mark on the dorsum. They move slowly, become gradually much darker and finally change into almost black. Swollen dead bodies of these aphids are stuck to the leaf surface of the plant among the other alive aphids. After a while, the parasitic wasp emerge through a hole pierced on the abdomen, dorsally (Fig. 17), leaving an empty black skin as the remnant of the host body.

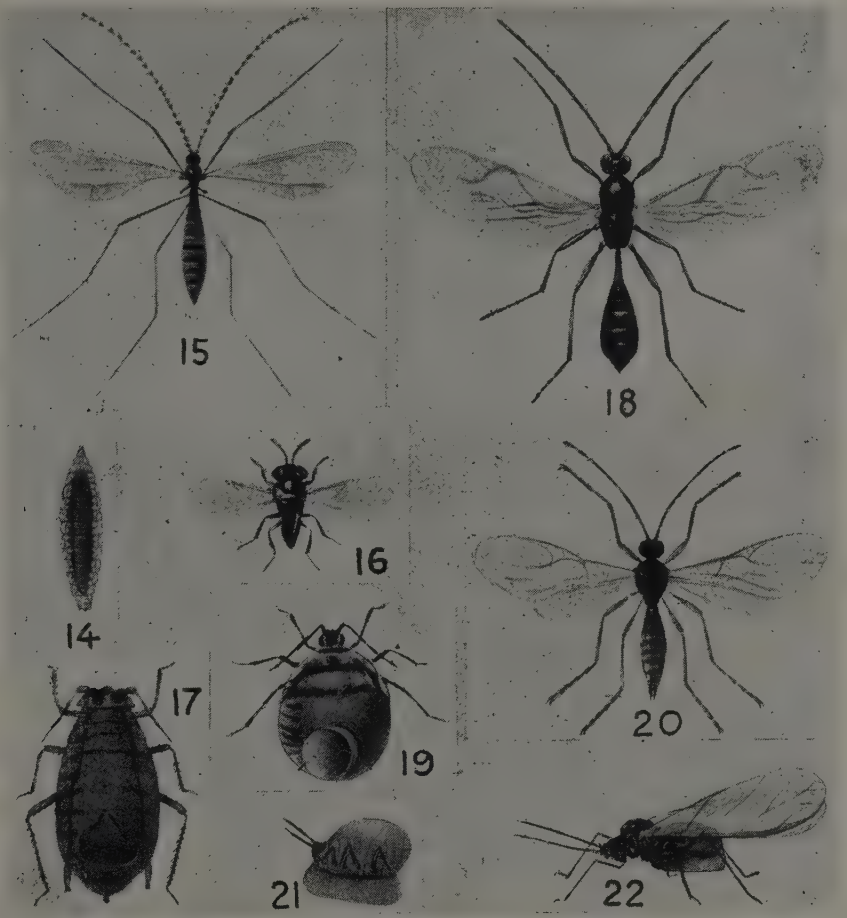

FIG. 14: Unidentified Cecidomyid maggot. — FIG. 15: Unidentified Cecidomyid. — FIG. 16: *Aphidencyrtus aphidivorus* Mayer. — FIG. 17: Apterous *Aphis maidis* showing on its obdomen, dorsally, the exit hole of *Aphidencyrtus aphidivorus*. — FIG. 18: *Aphidius sonchi* Marsh. — FIG. 19: Nymph *Aphis maidis* showing the exit hole of *Aphidius sonchi*. — FIG. 20: *Praon flavinode* Hal. — FIG. 21: Apterous *Aphis maidis* parasitised by *Praon flavinode*. — FIG. 22: Alate *Aphis maidis* parasitised by *Praon flavinode*. — (All Figures enlarged).

Apterous forms of *Aphis maidis* of all ages are attacked, but no alate forms were found parasitised.

Field observations showed that parasitised aphids occurred on maize tassels during mid-September and during the first half of October, and on maize cobs during October and November.

Examinations of severely infested maize plants in September, October and November, showed that the amount of parasitised *Aphis maidis* was 3% at the first week of September, 10% at the second week of September, 30% at the third week of September, 80% at the fourth week of September, during October and the first half of November, and 90% at the second half of November.

Ten parasitised *Aphis maidis* were isolated singly in tubes, and it was noticed that no more than one parasite emerges from its host.

Aphidius sonchi Marsh. (Fig. 18), a parasitic Aphidiid, was-first observed on *Aphis maidis* infesting barley in March, 1947, and maize in September. Parasitised aphids look as straw-coloured inflated dead bodies, sticked to the host-plant. The adult wasp emerges through a circular hole it does on the dorsum of its host (Fig. 19). Parasitised *Aphis maidis* amounted from 10 to 20% in April while it reached 80 to 90% on *Aphis durantae* Theo. infesting *Duranta plumieri* at the same month.

Praon flavinode Hal. (Fig. 20), another parasitic Aphidiid on both apterous (Fig. 21) and alate (Fig. 22) forms of *Aphis maidis*, was only observed on aphid colonies infesting barley in March and April.

Parasitised dead examples of the host were inflated, straw-coloured, resting on a cocoon formed by the parasite under the body of the aphid, from which the adult parasite issues. The parasitised aphids were generally present on the top of the leaves of barley, at a distance from the aphid colony, and they are less numerous than *Aphis maidis* parasitised by *Aphidius sonchi* Marsh.. 25% of the *Aphis durantae* Theo. colony infesting *Duranta plumieri* in March and April were parasitised, while only 10% of *Aphis maidis* on barley grown at the same period were found parasitised, and none of them on maize in September, October or November.

Although predators and endo-parasites are of great effect in limiting the abundance of *Aphis maidis*, yet, they appear too late in the season to be effective against the rapid reproduction of aphids.

SUMMARY

Aphis maidis Fitch. is a serious pest of maize, sorghums, barley and wheat in Egypt.

Severe infestations occurs on barley and wheat in February and March, and on maize in September and October.

This aphid attacks maize tassels prior to and after their expansion, leaves, and cobs, causing great harm to the crop, especially if the attack happens before fertilization.

It also attacks the heart, leaves, sometimes ears of sorghums, barley and wheat.

Degree of infestation varies according to the different varieties of maize, sorghums, barley and wheat.

The usual practice of controlling aphid attack by 0.1-0.15% spray of nicotine sulphate in soap emulsion is rather not practical. This is due to the great extension of maize and sorghum plants, and to the thick growth of barley and wheat. Besides, it is quite impossible for the spray to reach all hiding places of the insect; and above all, it was found that the cost of treatment exceeds the crop loss caused by the aphids.

Chemical control can only be practised in case of experiments on early severe infestations in small areas to retard spread of attack until natural enemies become effective enough to check the infestation.

Early planting of barley and wheat is of great help to let the plants ear become tougher, before aphids become a real danger.

The best control in maize is to cut at random some of the infested tassels, but not more than 25% of the total number of the field tassels, before time of pollination.

Removing gramineous weeds, especially *Panicum colonum*, on which the insect passes intervals between its different host crops, helps very much to reduce infestations.

The Hymenopterous parasite, *Aphidencyrtus aphidivorous* Mayer, is the most effective enemy. It destroys great numbers of *Aphis maidis* and checks its population.

Coccinellids, Syrphid larvae and *Orius* spp. also play an important role in that direction.

Other parasites, such as *Aphidius* and *Praon*, have but little effect.

ACKNOWLEDGMENT

The writer is very much indebted to Prof. Dr. Hamed Seleem Soliman the former Sub-Director of the Cairo University, for his supervision, criticism and the valuable suggestions he offered during this work; to Mohamed Soliman El-Zoheiry, ex-Director of the Crop Protection Department of the Ministry of Agriculture, for his continuous encouragement and help.

Thanks are also due to the well known Entomological Experts, Dr. Ch. Ferriere of the Geneva Museum, Dr. W.J. Hall of the British Museum, and to Prof. Dr. H. Priesner who have gratefully helped in insects identification.

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THE SOIL ARTHROPOD FAUNA IN A FARM AT GIZA, EGYPT

(with 18 Text-Figures and 5 Tables)

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CONTENTS

PART I : PRELIMINARY EXPERIMENT. — I. Introduction. — II. Soil organism defined. — III. Ecological notes. — IV. Method and technique. — V. Results and discussion. — VI. Summary.

PART II : FLUCTUATIONS OF FAUNAL MEANS THROUGHOUT A YEAR. — I. Introduction. — II. Fields selected for examination. — III. Botanical census of fields. — IV. Analyses of fields examined. — V. Meteorological considerations. — VI. Method and technique. — VII. Results and discussion. — VIII. Factors affecting faunal means. — IX. Summary.

PART III : MAGNITUDE AND DISTRIBUTION OF COLEOPTERA. — I. Introduction. — II. Fields examined. — III. Sampling and sampling tools. — IV. Extraction technique. — V. Results and discussion. — VI. Summary. — VII. Acknowledgments. — VIII. Bibliography.

PART I: PRELIMINARY EXPERIMENT

I. INTRODUCTION

The application of scientific conclusions resulting from soil investigations proves to be of an appreciable help to both the agronomist and the economic biologist. In countries where such investigations are carried out on a large scale, many agricultural problems and numerous difficulties have been solved. Preventive and remedial measures against harmful damages have been advocated (COBB, 1918). Farmers have been advised to follow certain agricultural rotation, to use certain soil fertilizers, to adopt certain cultural methods, and to apply suitable materials at the proper time with suitable quantities and qualities. Consequently, effective means for successful yielding and economic cropping have been aptly acquired.

In Egypt, however, soil investigations as a whole have not received deserved attention, although the country depends almost entirely on its agriculture. As far as the writer is aware, soil investigations have been mainly concerned to the physical and chemical properties. The soil founa, however, have not received attention although the Nile Valley presents a virgin field for research in that respect. It represents the land under cultivation which constitutes about 1/30 of the whole area of the country. The remaining vast area is a desert where no faunal change due to artificial or agricultural operations could exist. Its founa, if found, is only affected by the supervening atmospheric or meteorological conditions. The cultivated valley, on the contrary, has its rotational system of agricultural practice, which may vary in diferent districts of the valley and, consequently, is apt to produce an ever changing physical and organic environments. These, in turn, exert continuous effect on the existing soil fauna. This latter, however, is possibly characteristic as narrow valley is bordered on either side by a permanent barrier, viz: the vast western and eastern deserts, which are impassable by soil migrating fauna. Moreover, the valley extends from the Mediterranean to the Equatorial regions and its districts are thus lible to considerable variation in climatic conditions. The country is, therefore, divided into three main districts, viz : Upper and Middle Egypt which are narrow, and Lower Egypt (Delta) which is much broader and fan-like area extending to the Mediterranean sea. The altitude also varies considerably.

From the fore-going facts, it may be expected that the examination of the soil fauna in a certain area within a certain district may, to a certain extent, represent the whole district which is affected by the same physicol, chemical and climatic factors. The other districts are expected to vary considerably.

Very little has been done on the Egyptian soil fauna. HAFEZ (1939, 1942, 1947, 1948, and 1949) investigates and describes the insect fauna of the dung, likely to be met with in fresh or old farmyard manure and in the dung of the working or grazing animals. CASSAB (1938, 1941, and 1944) discusses certain biological aspects of the *Gryllotalpa gryllotalpa* L. and its distribution in the country. Most thysanuran insects pass one or more stages in the soil; and PRIESNERS' contributions (1929, 1930, 1931, 1932, 1933, 1934, 1935, 1937, 1938, 1948, and 1950) to the *Thysanura* in Egypt are well known. BISHARA (1934) investigated one limited area at Giza, with the idea of estimating the number of the larvae of *Prodenia litura* F. hiding in the soil.

The importance of *Arthropoda* among terrestial fauna, both as to number and economic importance gives it priority in investigation over other soil organisms. MCCOLLOCH (1926) states that 95% of all insect species invade the soil for various purposes, thus constituting an important factor in the soil environment.

An attempt has been done to obtain information as to the types of *Arthropoda* existing in the Egyptian cultivated soils, the relative abundance of the arthropod groups, and their distribution in various depths. The first part of the present paper gives the results of a preliminary experiment showing the magnitude of the arthropod soil fauna in an orchard under pear trees at Giza.

II. SOIL ORGANISM DEFINED

CAMERON (1913) defines the term "Soil insect" as including all insects which at one time or another in the course of their life-cycles spend one or more stages either *on* or *beneath* the soil surface. IMMS (1923) who upholds the fore-mentioned view, records that with so comprehensive definition the intimacy of association of soil animals with the soil would vary within very wide limits as to the short or long time they pass in the soil in one or various phases. THOMPSON (1924) who adheres to the previous definitions, includes in the term "Soil fauna" all the members of the Animal Kingdom, other than microscopic forms, occurring *on* the soil surface or *below* it.

CAMERON (1925-1926), in discussing again his definition of "Soil insect", records : "The true index of an habitat is its suitability for breeding as well as for feeding, and for the two the former is probably the more important. If we adhere strictly to this definition of habitat the number of species which our definition of soil insect includes would be greatly reduced". But, although CAMERON shows that the true habitat of some typical parasites as *Oestridae* is a mammalian host, that of certain thrips is the plant, he does not hesitate to consider them as soil insects because they pass one or more stages of their life-cycles in the soil. Finally, he concludes that he "preferred to neglect the criteria of an habitat so as to include within the meaning of the term "soil insect" all species that are at any time associated with the soil, no matter whether the period of association is long or short". JACOT (1936) gave a good classification of the soil fauna. Any organism existing in the soil may be influenced, according to PARK (1941), by its habitat (action) or this latter may be influenced by the organism (reaction). Between the soil organisms themselves, theire are many inter-relations (co-actions) which may be beneficial (co-operation), harmful (disoperation) or a fashion of competition, either inter-specific or intra-specific.

The writer, depending on the fore-mentioned views, considers as a "soil animal" any of the arthropod fauna extracted from the soil samples obtained from the soil by the sampling core auger.

III. ECOLOGICAL NOTES

This experiment was carried out in a pear orchard located in the farm of the Faculty of Agriculture at Giza. The farm exists about one mile in a direct line west of the River Nile, at an altitude of nearly 84 feet above sea-level. Giza lies on 30° 2' north latitude. The field selected for examination is a pear orchard where the pear trees, *Pyrus communis*, are situated in rows at equidistances of one yard each. The trees stand in wide ridges with beds between. Except of some weeds growing from time to time between intervals of harrowing, the soil remains bare all the year

round as no extra corps are grown. The prevailing weeds are mainly *Melilotus indicus, Convolvulus arvensis* and *Cyperus rotundus.*

The soil of this pear orchard is of the clay loam type as shown by the mechanical analysis (Table III, field F). Sampling was carried out at 8 a.m., when the temperature at that time was 22.8°C in the screen and the soil humidity was 21.5 (calculated after heating the soil at 105°C).

IV. METHOD AND TECHNIQUE

The four-inch core auger is the sampling unit recommended by various recent investigators (FINNEY 1941, YATES and FINNEY 1941, SALT and Hollich 1944, STRICLLAND 1944, and ROSS et AL., 1945). Twenty random samples were obtained with this unit to a depth of 15 inches below the soil surface. Smaller or larger sampling units as well as more or less number of samples were adopted by various workers on the soil fauna such as MORRIS (1922, 1927), IMMS (1923), THOMPSON (1924), EDWARDS (1929), JONES (1937), and LADELL (1938). Each sample was emptied in a special tin. After securing the sample, each tin was tightly closed and then the tins were transferred to the laboratory. The samples were soaked in water for no less than 48 hours at room temperature. Finally, each sample was washed and the arthropod fauna extracted according to the method described by SALT and HOLLICK (1944). Normal saline solution (1.18 sp. gr.) was used for flotation as referred to by LADELL (1936) and COCKBILL et AL. (1945). Benzene was used for extracting the arthropod fauna.

V. RESULTS AND DISCUSSION

The types and magnitudes of the arthropods obtained from the samples are shown in Table I.

A. Insecta

This class constitutes about 79% of the total soil Arthropoda. The mean per acre is 5.350.000 individuals represented as follows :

1. — THYSANURA. which represented 50.55% of the total arthropod fauna, or about 64% of the total insect fauna. They existed in all samples obtained; the number varying from 3 to 23 individuals per sample. They were belonging only to two genera, of which *Heterojapyx* spec. reached 97.8%, whilethe other genus *Anajapyx* spec. only 2.2%.

2. — COLEOPTERA was next to Thysanura, constituting 17.71% of the total arthropod fauna, or 22.43% of the total insect fauna. They existed in 75% of the samples obtained. About 77% of them were adults, the rest were larvae. These beetles are recorded in Table II, which shows also their magnitudes and percentages.

TABLE I

Types and magnitudes of soil Arthropod groups obtained from 20 samples

Fauna	Total Individuals obtained	Mean per sample	Percentages	Mean per acre in thousands	Range per acre in thousands
			A. Insecta		
Thysanura	137	6.85	50.55	3425	1000 - 11500
Coleoptera	48	2.40	17.71	1200	0 - 4500
Diptera	8	0.40	2.95	200	0 - 1000
Collembola	5	0.85	1.85	125	0 - 1500
Hymenoptera	3	0.15	1.11	75	0 - 500
Other insects	13	0.65	4.80	325	0 - 1500
Total	214	10.75	78.97	5350	1000 - 12000
			B. Other Arthropoda		
Myriapoda	16	0.80	5.90	400	0 - 1500
Mites	39	1.95	14.39	975	0 - 3500
Spiders	2	0.10	0.74	50	0 - 500
Total	57	2.85	21.03	1425	0 - 4000
			C. Total Arthropoda		
	271	13.55	100	6775	1500 - 12000

TABLE II

Magnitudes and percentages of Coleoptera obtained from 20 samples

Coleoptera	Number obtained	Percentage	Means per acre in thousands
Platystethus spec.	21	58.3	525
Pleurophorus caesus Gr.	5	13.9	125
Sitophilus granarius L.	3	8.3	75
Gibbium psylloides Czemp.	2	5.6	50
Tribolium confusum Duv.	2	5.6	50
Tachys scutellaris aegyptiacus Koch-Schatz.	2	5.6	50
Ochrolamus (*Dilarus*) *pictus* Bdi.	1	2.8	25
Total	36	100.0	900

3. — DIPTERA, COLLEMBOLA, and HYMENOPTERA constituted small fractions of the total arthropod fauna. Dipterous pupae made up 75% of the dipterous insects. *Mycetophilid* adults composed 12.5%, and the rest were *Anisopid* larvae. *Lepidocyrtinus incertus* Hand. of the Collembola made up 20% of the collembolans obtained. The

hymenopterous *Aegyptocelio frequens* constituted 66.7% of the hymenopterous fauna, while the rest belonged to *Chalcidid* spp.

Insects belonging to ORTHOPTERA and HEMIPTERA were obtained but were not identified.

B. Arthropoda other than insects

These composed about 21% of the total arthropod fauna. They are represented as follows :

1. — MYRIAPODA composed about 6% of the total fauna. SYMPHYLA made up 62.5% of the whole myriapod fauna; the rest consisted of the chilopod *Geophilus spec.* No *Diplopoda* or *Pauropoda* were met with.

2. — MITES composed 14.39% of the total arthropod fauna. *Galomna* spec. (Galomnidae) and *Liacarus* spec. (Liacaridae) made up 23.1% of the whole mite fauna; the *Pseudotritia* spec. (Phthiracaridae) 59%, *Epilohmannia* spec. (Epilohmanniidae) and *Laelaps* spec. (Laelaptidae) each 7.7%.

3. — Spiders composed a small fraction of the total arthropod fauna (0.74%).

VI. SUMMARY

1. — Definition of the "Soil organism" is discussed.

2. — Means and percentages of the total Arthropoda and the main arthropod groups are illustrated. These show that HEXAPODA (Insecta) exceeds other groups. THYSANURA and COLEOPTERA are more prevailing than other insects.

3. — MITES are next in magnitude to insects. MYRIAPODA are considerably more than spiders. No crustacean organism was met with.

PART II : FLUCTUATIONS OF FAUNAL MEANS THROUGHOUT A YEAR

I. INTRODUCTION

The Arthropod faunal means in the soil of an orchard under pear trees has been treated in Part I. These means gave a mere conception about the Arthropod magnitudes during one month only. The present Part II. gives the faunal means during the other months of the year, and discusses the fluctuations during these months.

II. FIELDS SELECTED FOR EXAMINATION

Six fields in a farm at Giza were selected, representing the prevailing soil type not only in the farm but in almost the whole cultivated district. These fields, designated by the letters (A) to (F), can be described as follows :

1. — Field (A) has been, since 1933, under *Trifolium alexandrinum* L. (berseem or clover), followed by fallow. During these years it did not receive any kind of manure. Consequently the clover yields which were estimated annually were nearly deteriorated. Weeds were so common as to prevent estimation of the crop in some years.

2. — Field (B) is contiguous to field (A.). It has been also, since 1933, alternatively under clover for one year, and wheat (*Triticum spec.*) for the other. When under clover it did not receive any kind of manure, but when under wheat it received a nitrogenous artificial manure at a rate of 100 kgs. sodium nitrate or 75 kgs. ammonium sulphate per acre.

3. — Field (C) was under clover followed by fallow during the period of the present investigation. Contrary to field (A), it received artificial manure at a rate of 100 kgs. superphosphate per acre. The crop grown prior to clover in this field was barly followed by Sudan grass.

4. — Field (D) was under cotton (*Gossypium* spec.) followed by a short fallow which was followed by clover. Before cotton, it was under clover or barly followed by Sudan grass. It received an artificial manure at a rate of 100 kgs. superphosphate for clover or cotton, or 100 kgs. sodium nitrate for barley per acre.

5. — Field (E) was used for vegetable cropping. It was under tomato (*Solanum* spec.) followed by a short fallow which was followed by cabbage (*Brassica oleracea capitata*). Tomato as well as cabbage received farmyard manure at a rate of 100 cubic metres per acre, and artificial manure at a rate of 100 kgs. sodium nitrate per acre.

6. — Field (F) was under pear trees (*Pyrus communis*) which were grown at equidistances of about one yard apart. The trees were rowed on wide ridges separated by somewhat lower beds which remained bare all the year round. These beds received a dressing of farmyard manure at a rate of 100 cubic metres per acre in January.

III. BOTANICAL CENSUS OF FIELDS

Both fauna and flora are linked with each other. Besides the ordinary crop in the field, there may be other weeds by which the fauna may be affected positively or negatively. Some weeds may give an indication as to soil fertility, or type. Accordingly, it was important to record the prevailing weeds in the fields examined and their relative numbers during the period of the present investigation which lasted for one year.

The method adopted to illustrate this batonical census for each field consisted, according to EDWARDS (1929), in counting the weeds existing in five random areas, each of one square yard. Other notes concerning the flora in general were recorded. The estimation of weeds was carried out in February 1952, but other remarks prior to that month were added.

1. — The mean number of weeds per yard in field (A) was 54 plants of which *Avena fatua* (the wild oat) composed 43.0%, *Cichorium* spec. (wild chicory) 25.5%, and *Emex Spinosus* 20.3%. *Cynodon dactylon* (the dog's tooth grass), though small in February that it was too small to be counted, became so common in March and April that it covered the soil surface. At the border of the field certain weeds were numerous than elsewhere. *Avena fatua* seemed to replace clover in such places at that time. Other prevailing weeds at the boder were *Sinapsis juncea* (charlock), *Beta vulgaris*, *Euphorbia peplus*, *Lamium amplexicaule*, *Rumex dentatus*, and *Sonchus oleraceus*.

2. — The mean number of weeds per yard in field (B) was 62.8 plants, of which *Cichorium* spec. amounted 44.9%, *Avena fatua* 39.5%, and *Emex spinosus* 9.8%.

3. — The mean number of weeds per yard in field (C) was 63.0 plants, of which *Cichorum sp.* formed 27.9%, *Lolium temulentum* (darnel) 11.4%, *Avena fatua* 8.9%, and *Ammi sp.* 7.0%. The weeds *Lepidium sativum* (Garden grass), *Beta vulgaris* and *Convolvulus arvensis* each composed 5.7%. The following weeds also existed: *Rumex dentatus* (5.4%), *Chenopodium murale* (4.8%) *Sonchus oleraceus* (4.4%), *Medicago hispida* (4.4%) *Cynodon dactylon* (3.8%), *Panicum glucum* (3.2%), and *Euphorbia peplus* (1.6%).

In this field large patches of weeds were fairly common as to replace totally the ordinary crop. Such patches contained the same kinds of weeds above-mentioned, but were avoided during sampling for weeds.

4. — The mean number of weeds per yard in field (D) was 77.8 plants, of which *Lepidium sativum* formed 44.2%, *Cichorium* spec. 27.2%, *Tolium perenne* 10.8%, and *Chenopodium murale* 5.7%. During the cotton crop, the weeds were rare due to continuous harrowing. In August and September, when harrowing was ceased, certain weeds as *Panicum colonum*, *Solanum nigrum*, *Convolvulus arvensis*, *Corchorus olitorius*, and *Anagallis arvensis*, were observed in distant places among the cotton plants.

5. — The mean number of weeds per yard in field (E) was 31.0 plants under fallow in February. The common weeds were *Chenopodium murale* (49.0%), *Sonchus oleraceus* (17.4%), *Capsella bursa pastoris* (11.0%), *Lamium amplexicaule* (7.1%), *Medicago hispida* (5.8%), and *Tolium perenne* (5.2%). Under cabbage, theweeds were rare due to continuous harrowing. Under tomato they were also scarce, but in April and May 1951 certain weeds as *Orobanche ramosa*, *Portulaca oleraceae*, *Solanum nigrum* and *Convolvulus arvensis* were observed, the former two being more frequent.

6. — The weeds existing in field (F) were neither abundant nor uniformly distributed. Their scarcity was due to continuous harrowing. Certain weeds were observed in small patches, or singly, from time to time during the year, particularly after irrigation. Such weeds were *Melilotus indicus*, *Panicum colonum*, *Convolvulus arvensis*, *Cichorium* spec., *Ammi* spec., *Sonchus oleraceus*, *Chenopodium murale*, and *Cyprus rotundus*.

IV. ANALYSES OF FIELDS EXAMINED

Soil inhabitants may be more or less affected by the type of soil in which they exist, either in number or kind. This variation is possibly due to soil structure which in turn exerts other factors related to water-holding capacity, temperature changes, areation, etc. Accordingly, the mechanical analyses of the fields chosen for faunal examination seemed to be necessary in the opinion of many investigators such as CAMERON (1925-26), MORRIS (1920, 1922, and 1927), THOMPSON (1924), and EDWARDS (1929).

Five samples were taken at random from each field to a depth of 15 inches below the soil surface. These were bulked and mixed throughly to form one composite sample. The six composite samples representing the six fields were mechanically analysed, after the method of the Agricultural Educational Association (1927). All figures were based on oven dry soil (105 °C.). The soil textural class was defined by using the tringle system illustrated by EMERSON (1930). Some chemical analyses were also carried ont. The mechanical and the chemical analyses carried out are shown in Table III.

TABLE III

Mechanical and chemical analyses of fields examined

	A	B	C	D	E	F
Coarse sand.....	1.46	1.09	1.67	0.76	2.02	1.54
Fine sand	28.59	27.51	34.87	42.43	44.72	42.24
Silt	30.79	29.09	23.10	20.58	24.82	27.00
Clay.....	35.07	37.18	35.39	31.80	23.99	25.26
Carbonate (Ca CO3) ..	1.69	3.16	2.44	2.26	2.01	2.03
Hg. water.....	6.39	6.63	5.89	5.80	6.25	5.15
	8.51	8.58	7.98	6.57	6.24	6.16
	8.8	8.9	9.0	8.9	8.2	8.6
Loss on solution						
1. Iron ($Fe_2 O_3$)	2.22	2.34	2.42	2.35	2.38	2.35
2. Calcium (Ca O) ...	1.49	1.67	1.65	1.44	1.34	1.64
3. Magnesium (Mg O)	0.12	0.12	0.09	0.18	0.09	0.11
Soil Type	Light clay soils				Clay loams	

These analyses showed that the fields selected could be classified into two soil types, viz : the light clay representing fields (A), (B), (C), and (D), and the clay loam representing fields (E) and (F). With the exception in the percentage of carbonate, the first two fields are nearly similar. Being contiguous and under similar environmental conditions, difference in their fauna could possibly explain the effect of crop rotation system which had been dominating since 1933 in the two fields.

Perhaps the difference in the percentage of carbonate was due to the artificial nitrogenous manure added to field (B) when under wheat.

The plasticity of fields (A), (B) and (C) due to their higher percentage of clay, might be somewhat regulated by the slightly higher percentages of the organic matter they contained. Though field (D) showed similarity to the previous fields in the soil type, it had a markedly higher percentage of fine sand accompagnied by a lower percentage of clay. This actually made field (D) stand on the border between the two soil types.

Fields (E) and (F) were nearly similar, being of one soil type, the clay loam, but the former seemed to be somewhat lighter than the latter. Both fields had lower percentages of organic matter than other fields.

The chemical figures tabulated under the loss on solution and the pH in Table III, showed an approximate similarity and consequently the faunal differences due to these two factors might be possibly neglected.

V. METEOROLOGICAL CONSIDERATIONS

The meteorological conditions supervening in the district exert a considerable effect on both the fauna and the flora. Some of these factors are here after briefly illustrated in Giza region.

1. — December 1951 was the rainiest month with an average rainfall of 44 mms., while February 1952 was second with an average of 10.7 mms. An average of 2.1 mms. was recorded for January, 0.5 mms. for November, while other months were almost rainless.

As water for irrigation is sufficient throughout the year, the rainfall at Giza seems to have a limited effect due to both its comparative scarcity and to sufficient humidity preserved by soil through irrigation.

2. — SUTTON (1946) in discussing the temperature of the cultivated land at Giza region, stated that it varies in neighbouring cultivated fields or even in the different points in the same field, according to numerous local factors. The temperature degrees given presently were either obtained from the Meteorological Station of the Cotton Research Board located in the neighbourhood of the fields examined or from the Meteorological Station of the farm itself. They were registered by thermometres erected after the manner described by CONNEL (1923) or KEEN and RUSSEL(1921). Single-point temperature informations as obtained from these stations illustrated only the temperature conditions *prevailing in Giza cultivated land as a whole* and might not at all times represent exactly those existing at the specified fields or depths. Figures give a conception about the air and earth temperature conditions prevailing in the cultivated land at Giza during the period of the present work.

SUTTON (1946) states that a pronounced heat wave occurs at Giza in February and another at the end of October or early in November. Figure 2, quoted from him, shows this phenomenon.

3. — According to SUTTON (1946) the water-table at Giza fluctuates between 130 to 200 cms. or more from the soil surface and seems to have no effect on the temperature of the upper soil strata. This also was noted by TAYLOR and BURNS (1924) and by GRAY and NASSAR (1928). As water irrigation is sufficient and constant, the effect of water-table at Giza on soil humidity is not noticeable.

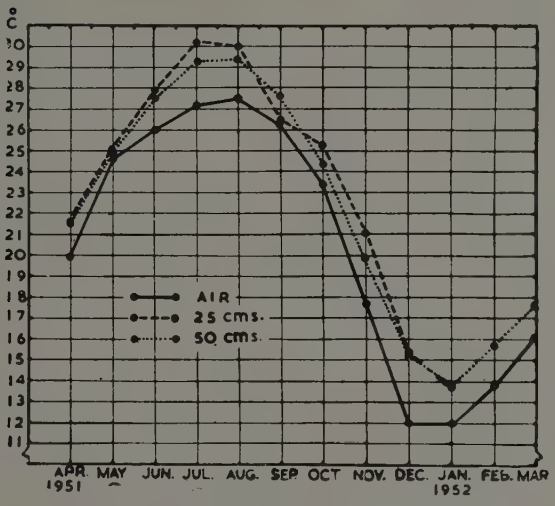

FIG. 1: Montly mean temperature in cultivated land at Giza (1951-1952).

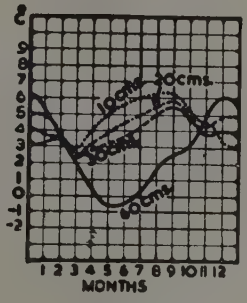

FIG. 2 : Soil heat waves at Giza (after SUTTON, 1946).

4. — The effect of vegetative covering on temperature is given in the following notes, which are based on results obtained by GRAY and NASSAR (1928) or TAYLOR and BURNS (1924) from their work carried out in cultivated land at Giza :

(*a*) Under fallow, the range of temperature decrease rapidly as the depth increases. The decrease is more regular from 20 to 30 cms. than in the layer above.

(*b*) The maximum temperatures at all depths are higher under berseem than under wheat.

(*c*) The range of temperature under cotton at 5 and 10 cms. depths is wide during the period March-June when the plant does not shade completely the soil surface, but it becomes narrower, being almost constant during the period August - October.

(*d*) Under sharaqi (fallow land not irrigated for a long period during summer) the surface temperature may reach about 68°C. in July and August though the highest average monthly maxima at all depths down to 20 cms. occur in July, during which partial sterilization of the soil would be most intense.

VI. METHOD AND TECHNIQUE

1. — The botanical cencuses of fields examined as well as their mechanical and chemical analyses, were carried out as illustrated previously.

2. — Random samples were adopted. These were distributed all over the area examined as recommended by various workers as JONES (1937), LADELL (1938), COCHRAN (1938), and FINNEY (1941). From each of the six fields chosen one hundred random samples (treated by the washing method) were obtained to estimate the fauna. This number of samples was obtained in fives; each five ssmples were taken from each field at an interval of about three weeks. The area sampled was divided into five proximate sections from each of which a random sample was obtained each time.

The four inch diameter core auger is the sampling apparatus adopted for sampling soil arthropod fauna by most racent workers such as STRICKLAND (1944) SALT and HOLLICK (1944), COCKBILL et AL. (1945). The advantages of this unit, as recorded by STRICKLAND (1944), are its light weight, speed of operation and ease of cleaning. Other devices have been used for obtaining soil samples by other workers as MORRIS (1922), IMMS (1923) and JACOT (1936). In the present investigation, the four diameter unit was used, and was driven to obtain a sample at a depth of 15 inches below the soil surface. Larger or smaller samples were taken by various investigators such as MILES and PETHERBRIDGE (1927), THOMPSON (1924), EDWARDS (1929), MACCOLLOCH et AL. (1927), RAWLINS (1934), and FLEMMING and BAKER (1936).

3. — The extraction of fauna from soil samples was the most difficult problem that faced biological investigators. The methods used before LADELL (1936) were either unsatisfactory or tedious and consequently less suitable for faunal quantitative processes. PHILLIPS (1931) recorded and explained some of these methods. The flotation in a liquid medium method is considered to be the most recent and suitable one. It was initiated by LADELL (1936), adopted and improved by SALT and HOLLICK (1944), STRICKLAND (1944) and COCKBILL et AL.(1945). This was the method used in the present work. The technique was almost similar to that of SALT and HOLLICK, with some slight modifications to suit local circumstances. The extraction steps are briefly explained as follows :

(*a*) The five samples obtained from any field were put together in a special tin and transported to the laboratory where enough water was added to the samples. These were left to be soaked for at least 48 hours. Soaking was carried out at room temperature, as no suitable equipment for freezing was at hand. Freezing, which was recommended by SALT and HOLLICK (1944), was compensated by careful washing as advocated by CHOCKBILL et AL. (1945).

(*b*) The washing and extracting processes were carried out by an apparatus similar to that of SALT and HOLLICK; but the capacity of the first and second sieves, the guards and the reservoir were more enlarged to receive satisfactorily the bulked larger samples. The process of washing is shown in Figure 3. Explanation of

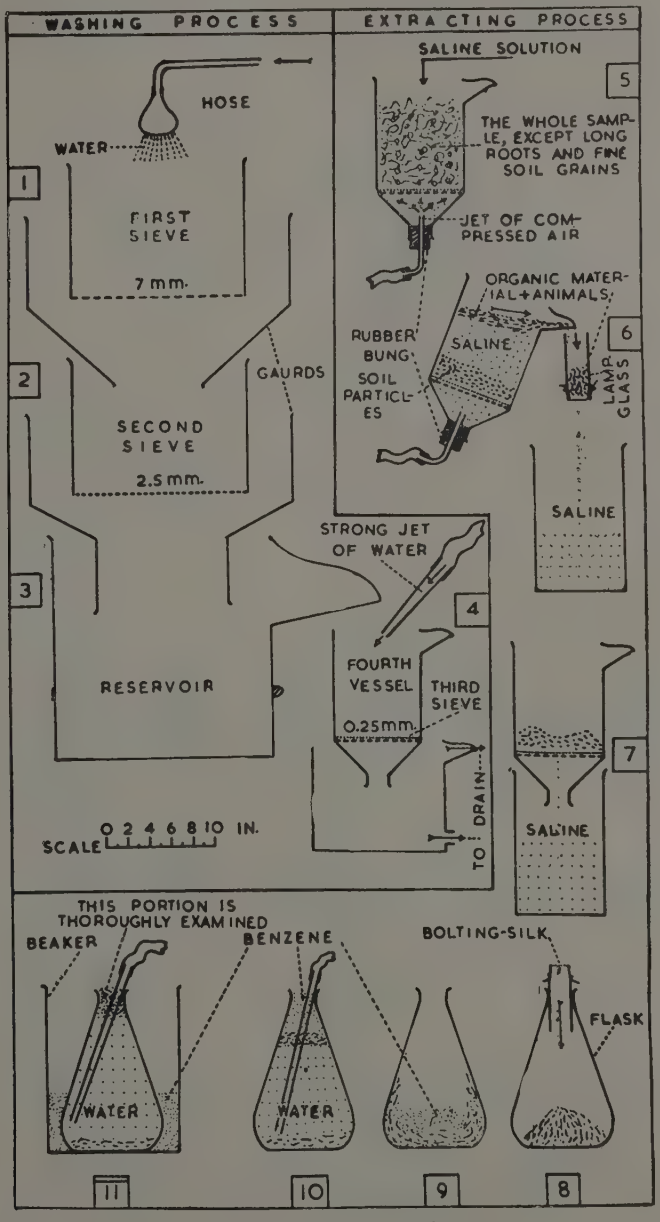

FIG. 3 : Extraction technique.

the steps is fully discussed by SALT and HOLLICK (1944), and will not be repeated here. Saline was used for flotation and benzene for extraction.

VII. RESULTS AND DISCUSSION

The area of a four diameter inch core auger, the unit used in the present work, is almost exactly one-five-hundred-thousandth (1/500.000) of an acre (FINNEY 1941). In other words, a single individual obtained in any composite sample (constructed of five random ones) represents 100.000 individuals per acre. The faunal means will be given in the following discussion for the total Arthropoda, for the Insecta for Mites and for other arthropods.

1. — The average numbers experessing the total arthropod fauna per acre per annum could be adopted as a rough measure of the magnitude of the fauna.

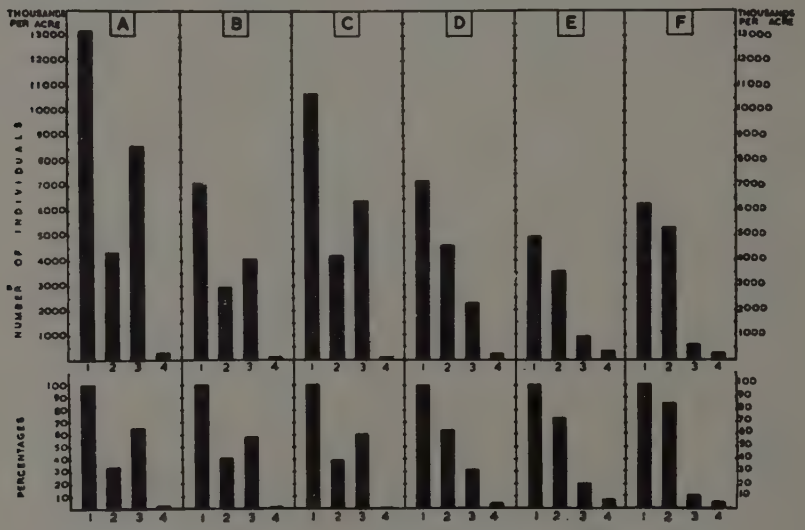

FIG. 4 : Faunal means per acre per annum and percentages: (1) Total Arthropoda, (2) Insecta, (3) mites, (4) other Arthropoda. — (A) to (F) : fields examined.

Figure 4 represents the means for both the total arthropod fauna and its major components. The following remarks could be deducted.

(*a*) The highest mean for total fauna per acre per annum was met with in field (A) where berseem was grown as one crop rotation without any kind of manure. The next high mean was found in field (C), also under berseem grown as one crop rotation but receiving artificial manure.

(*b*) In fields (B) and (D) where the two-crop-rotation system was followed the means were comparatively moderate. This may be due to the numerous cultural aperations required.

(*c*) The lower means were met with in fields (E) and (F) devoted for vegetables and pear trees respectively.

(*d*) The means were in general higher in the light clay soil type (fields A, B, C and D) than in the clay loam soil type (fields E and F).

(*e*) The means of the components of Arthropods varied greatly, but in general the following fact could be clearly noticed. Higher percentages of Mites accompagnied by lower percentages of Insecta and other Arthropoda dominated in the light clay

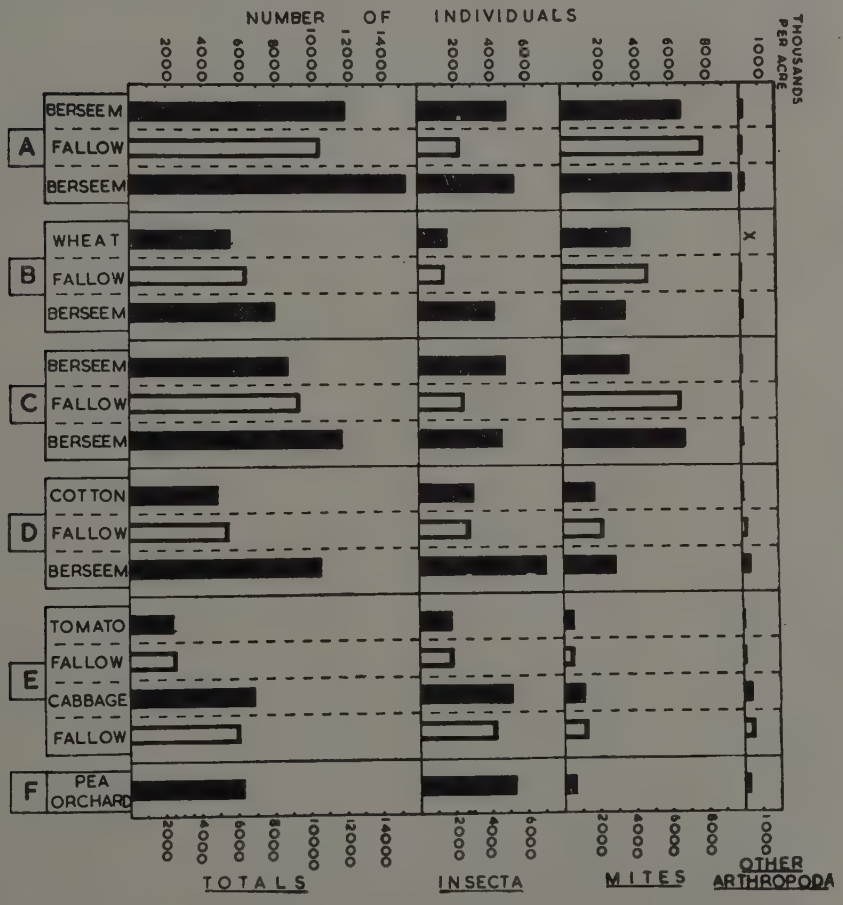

FIG. 5 : Faunal means per acre under various rotational periods.
(A) to (F) : fields examined.

soil type of fields (A), (B) and (C), while the reverse occurred in the clay loam soil type of fields (E) and (F). Field (D) stood as intermediate in this respect and this may be related to its mechanical analysis (see page 239).

(*f*) Arthropoda other than both Insecta and mites formed a small fraction of the soil arthropod fauna. Fluctuations of means were great as denoted by the faunal ranges.

2. — The means per acre under different crops, vegetables or fallows are shown in Figure 5. It could be noticed :

(*a*) The highest means for total fauna were met with under berseem as compared by other crops. Under berseem the means varied from field to field, but in general they were higher when the one-crop rotation system was followed (fields A and C) than when the two-crop rotation system was adopted (fields B and D).

(*b*) Other faunal means under other crops varied greatly.

(*c*) The relative insect percentages under different rotational periods were generally lower (with some exceptions) than the mite percentages in the light clay soils (fields A, B and C), while the reverse existed in the clay loams (fields E and F). Field (D) resembled the latter fields.

(*d*) The relative insect percentages under different fallows (Table IV) were lower than the percentages under both the preceeding or succeeding crops

TABLE IV

Faunal percentages and deviations from fallow under different rotational crops

Fields	Rotation	Percentages				Deviations from fallow		
		Total	Insecta	Mites	other Arthrop.	Insecta	Mites	other Arthrop.
A	Berseem	100	41.39	56.67	1.94	+ 18.31	— 18.50	+ 0.19
	Fallow.....	100	23.08	75.17	1.75			
	Berseem	100	35.42	62.50	2.08	+ 12.34	— 12.67	+ 0.33
B	Wheat.....	100	30.73	69.27	0.00	+ 7.60	— 6.50	— 1.10
	Fallow.....	100	23.13	75.77	1.10			
	Berseem	100	53.28	44.86	1.86	+ 30.15	— 30.91	+ 0.76
C	Berseem	100	55.85	43.39	0.75	+ 28.07	— 28.19	+ 0.11
	Fallow.....	100	27.78	71.58	0.64			
	Berseem	100	40.09	58.92	0.99	+ 12.31	— 12.66	+ 0.35
D	Cotton	100	62.19	35.98	1.83	+ 9.46	— 5.84	— 3.62
	Fallow.....	100	52.73	41.82	5.45			
	Berseem	100	67.02	28.13	4.85	+ 14.29	— 13.69	— 0.60
E	Tomato.....	100	73.95	23.30	2.75	+ 2.74	— 0.94	— 1.80
	Fallow.....	100	71.21	24.24	4.55			
	Cabbage ...	100	75.16	17.39	7.45	+ 3.95	— 6.85	+ 2.90
	Fallow.....	100	69.28	20.92	9.80	+ 5.88	— 3.53	— 2.35
F	Pear ochard ..	100	84.56	10.45	4.99			

in all fields, while the reverse happened in the case of mite percentages. Table IV also shows that the deviations of fauna under fallows succeeded or preceeded by berseem were more wide than under fallows preceeded or succeeded by other crops.

(*e*) Deviations in light clay soil type were in general wider than in clay loam soil type in case of Insecta and Mites. The reverse seemed to occur in case of Arthropods other than insects and mites.

3. — The fluctuation of faunal means during the whole months of the year were recorded for each of the six fields and illustrated by the polygons in Figure 6. The following remarks could be deducted :

(*a*) The peaks of polygons are noticed to occur generally in the period October-February (late autumn, winter and early Spring). Under pear orchard, the period seems to occupy the whole three seasons (field F); the peaks occur during Spring and early summer. In the first four fields (A to D) the high means were occurring under berseem.

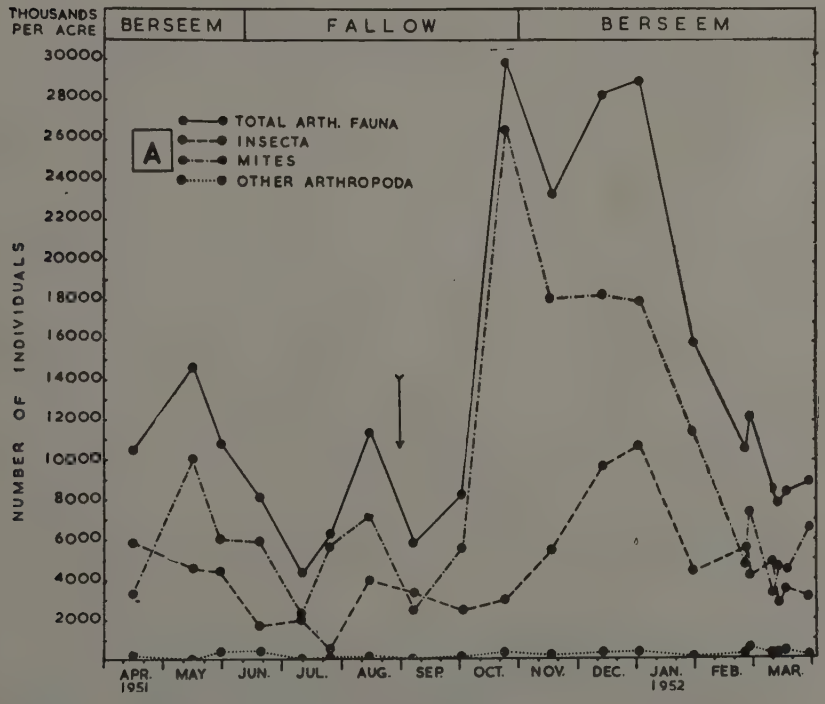

FIG. 6 : Fluctuation of faunal means per acre throughout the year in field (A). — Vertical arrow refers to date of ploughing.

(*b*) Lower means seem to happen during the period May-September and especially during the summer period when the temperature degrees were high and the land in most cases were bare.

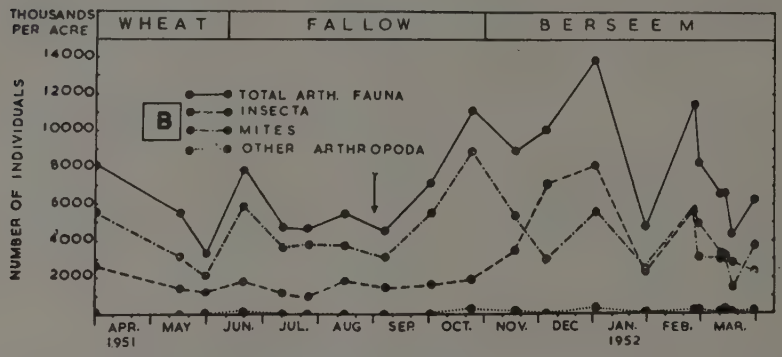

FIG. 7 : Fluctuation of faunal means per acre throughout the year in field (B). — Vertical arrow refers to date of ploughing.

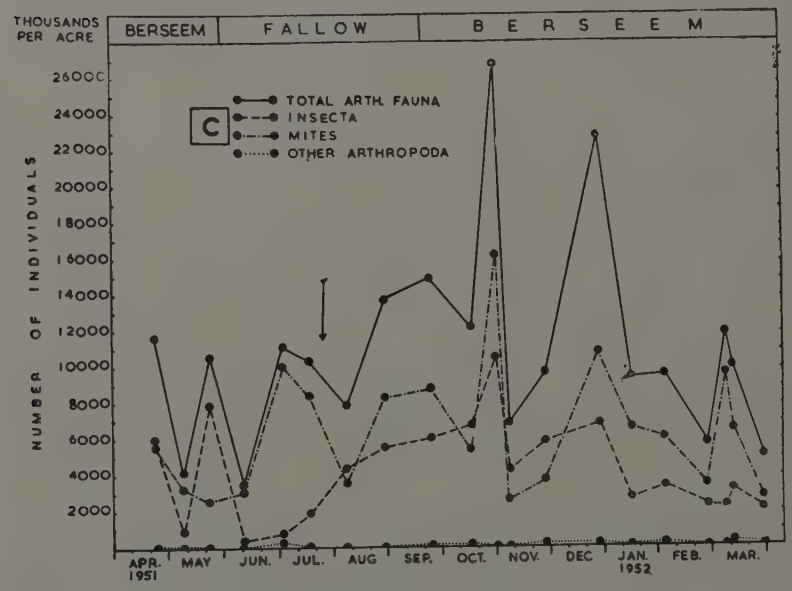

FIG. 8 : Fluctuation of faunal means per acre throughout the year in field (C). — Vertical arrow refers to date of ploughing.

(*c*) In the light clay soil type (fields A, B and C) the mite fauna supervened the inseet fauna throughout the year. The reverse was obviously noticed in the clay loam soil type (fields E and F). Field (D) seemed to be intermediate in that respect or rather merging to be classified with the latter two fields.

VIII. FACTORS AFFECTING FAUNAL MEANS

Fluctuations of faunal means are due to numerous and inter-connected factors (Townsend 1924, and Gray 1932). The individual influences of each factor are almost impossible to assess by the present work but other experiments are required to determine them concisely. The following are some observations which accumulated during this work and which are worthy of recording though further verifications are necessary.

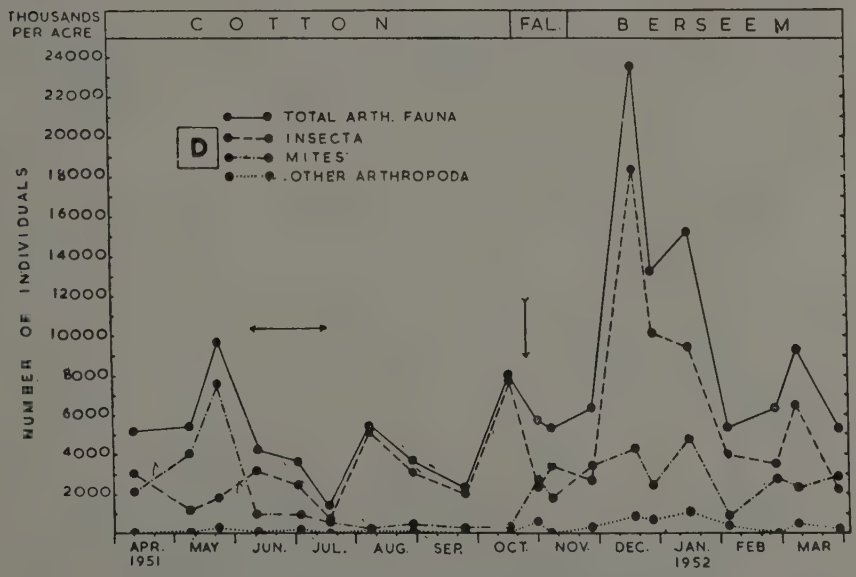

Fig. 9 : Fluctuation of faunal means per acre throughout the year in field (D). — Vertical arrow refers to date of ploughing; horizontal arrow refers to period of dusting.

1. — By comparing (Figure 1 with Figures 6 to 11) it is noticed that the higher faunal means occurred when temperature means were generally lower. The former happened in seasons other than summer. Fallow periods generally take place during this season when the soil is generally dry. An abrupt drop in the faunal means was

noticed to occur in autumn period (Figs. 6 to 11) and this may possibly be due to the soil temperature waves referred to by SUTTON (Fig. 2).

2. — It was noticed that the faunal means under berseem were higher than under other crops or fallows (Fig. 5). This may be due to the relative higher maximum temperatures under berseem in winter as recorded by GRAY and NASSAR (1928).

3. — Concerning the soil type, it was noticed that the total faunal arthropod means in the light clay soils were in general higher than those in the clay loams.

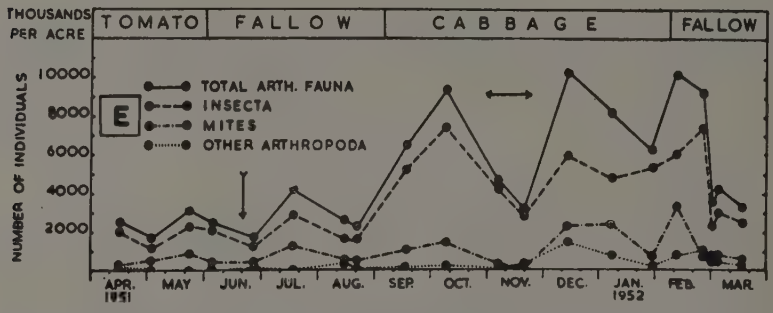

FIG. 10 : Fluctuation of faunal means per acre throughout the year in field (E). — Vertical arrow refers to date of ploughing; horizontal arrow refers to period of dusting.

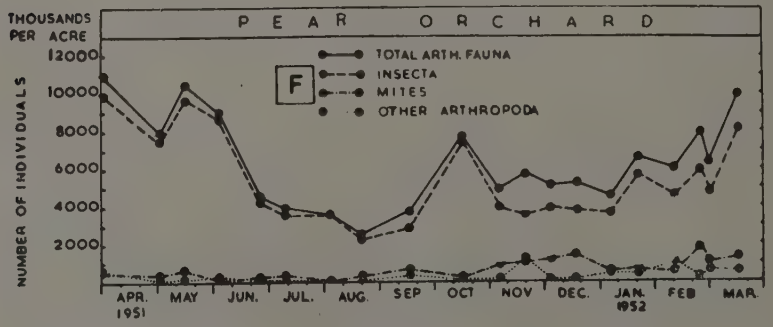

FIG. 11 : Fluctuation of faunal means per acre throughout the year in field (F).

In the former type the mite faunal means exceeded those of the insect means, while the reverse happened in the latter soil type (Figs. 6 to 11).

4. — The faunal means under the one-crop rotation system were generally higher than under the two-crop rotation system.

5. — Unmanured berseem possessed higher faunal means than under berseem receiving artificial manure (Fields A and C).

IX. SUMMARY

1. — Description of fields selected together with botanical census, mechanical and some chemical analyses are illustrated.

2. — Meteorological conditions prevailing at Giza cultivated land are discussed.

3. — Faunal means of six fields and under several crops are given : (a) per acre per annum, (b) per acre under various rotational periods, (c) per acre throughout the year.

4. — Factors affecting the faunal means are briefly discussed.

PART III: MAGNITUDE AND DISTRIBUTION OF COLEOPTERA

I. INTRODUCTION

Beetles, according to JACOT (1940), affect the soil by making burrows into which they lay eggs, pupate or form retracts for hibernation. They may feed on plant roots. In Egypt, ALFIERI (1936) found that the beetle, *Baris* (*Aegyptobaris*) *arctithorax* Pic was injurous to *Portulaca oleraceae*. Definite burrows are made and definite and characteristic soil types are preferred by certain coleopterous species (JACOT, 1940). STRICKLAND (1944) records that beetles comprise an extremely important fraction of the soil fauna, both from the economic and ecological standpoints. This investigator explains the functions of several coleopterous families. He refers to Staphylinids as the most characteristic soil inhabitants of tropical forest and plantation soils because of their predominantly predaceous habits. He also states that the staphylinid beetles are probably the most important soil animals in preventing an uncontrollable increase in the mite-springtail complex that forms their chief food supply. On Kansas prairie, JACOT (1936) recorded that one species of scarabaeid beetle was said to be responsible for digging 200 burrows per acre, for carrying 21 pounds of air-dried dung, and for excavating 126 pounds of the soil.

The magnitude of Coleoptera in the soil as well as their function and the number of species existing, have been discussed by many investigators working on the soil fauna such as BUCKLE (1921), MORRIS (1920, 1922 and 1927), IMMS (1923), THOMPSON (1924), CAMERON (1925-26), EDWARDS (1929), GRAY (1932), and GHILAROV (1937). The literature on the elaterid wireworms is much voluminous.

Their population density, control, effect on various crops and the methods of their extracting from the soil were discussed by many investigators, especially in England, and reference could be made to REOBUCK (1924), MCCOLLOCH et AL. (1927), MILES and PETHERBRIDGE (1927), BRYSON (1930), SHIRCK (1930), LEES (1934), RAWLINS (1934), JONES (1937), LADELL (1938), HAWKINS (1939), Advisory Entomological Conference (1941 and 1948), ANNON (1940, 1941 a, 1941 b, and 1943), FINNEY (1941), YATES and FINNEY (1942), BENNET and KEARNS (1942), SALT and HOLLICK (1944, 1946 and 1949), COCKBILL et AL. (1945), MILES and MILES (1945), DUNN et AL. (1946), and ROSS et AL. (1947 and 1948).

The present Part III gives a conception about the magnitude, distribution and species existing in cultivated land of a farm at Giza. As far as the writer is aware, no work as such has been carried out in Egypt, and similar investigations are hoped to be done in other districts.

II. FIELDS EXAMINED

Six fields were selected for examination and were designated A, B, C, D, E and F. The description and botanical census of these fields, their mechanical and chemical analyses were shown in Part II of this paper. Accordingly, the first four fields are of the light clay type while the other two fields are of clay loam. In Part II also, the meteorological conditions prevailing in Giza district were also recorded.

III. SAMPLING AND SAMPLING TOOLS

A. Method of sampling

Not only random sampling was adopted, but also the samples obtained were distributed all over the area selected for examination. Each field chosen was divided into five approximate sections from each of which a random sample was obtained. One hundred samples (Treated by the washing method) per field were obtained. For the sake of obtaining knowledge about the fauna throughout the year, this number was obtained in fives, each five random samples were taken from each of the six fields at an interval of about three weeks (sometimes it was necessary due to certain circumstances to shorten or lengthen this interval). The sampling unit was a cylinder with an internal diameter of four inches. The sample obtained was divided into four strata as follows : 0-3, 3-6, 6-10, and 10-15 inches, and these strata were designated respectively by the Roman numbers I, II, III, and IV. The description of the cylinder, as well as the method of obtaining and dividing the samples from each field, are illustrated hereafter. The similar strata taken from each field at a time were bulked together.

B. Sampling tools

The 4 inch diameter core auger, adopted in the present work was intended to remove four successive layers of the soil from the surface to a depth of 15 inches downwards. As the ordinary plough used by the Egyptian farmers disturbs approximately the six upper inches of the soil in the cultivated land, it was desirable to study both the strata affected and unaffected by ploughing.

The sampling apparatus was a cylinder (Fig. 12) of mild steal, 4 inch in diameter and about 21 inch long. The lower cutting edge of the apparatus was sharpened in order that it might be easily driven when hammered. Slots were cut half-way across

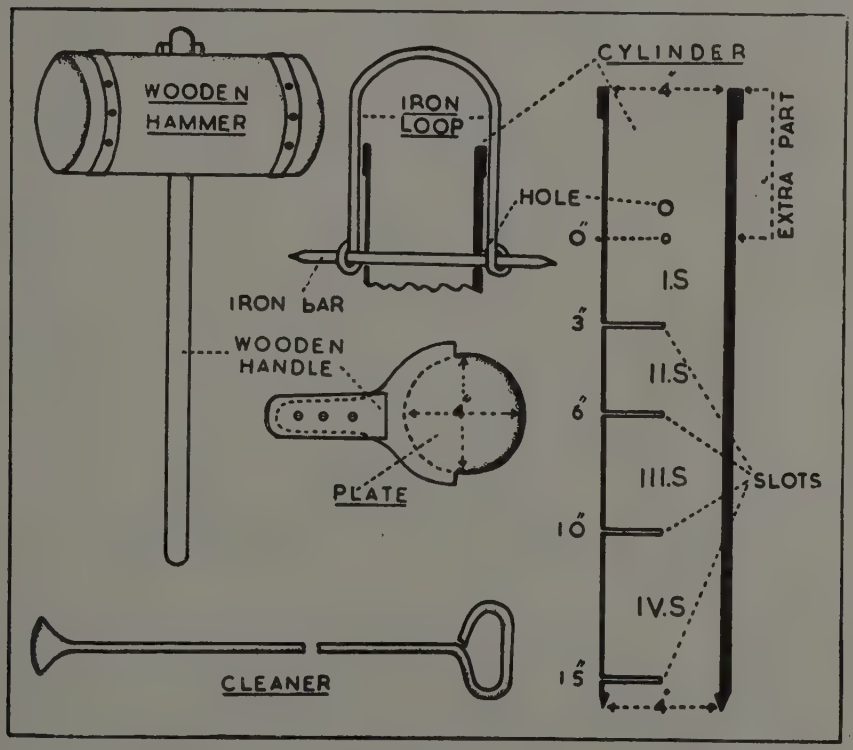

FIG. 12 : Sampling tools.

the tool at definite positions, after the manner described by PICKLES (1933). The actual sampling part of the tool was exactly 15 inches of its length. Below this part there was one extra inch which was the cutting portion of the tool. There was an extra upper portion of about 5 inches for use in hammering, withdrawal and handling

of the tool. The uppermost edge of the cylinder was much strengthened to withstand hammering. Plates (Fig. 12) which could be inserted in slots made in the cylinder and which divide tightly the latter into chambers, aided in procuring the desired successive strata by dividing the sample obtained (Fig. 13, step 3).

The process of dividing the sample into strata (Fig. 13) may be illustrated as follows :

1. — The sampling 15 - inch portion of the tool was demarked from its accessory upper part by two small holes (Fig. 12), one on either side (at 0 inch). These two holes were intended to indicate, when the tool was rightly hammered into the soil, the limit to which the surface of the soil inside the tool should reach.

2. — At a distance of 3 inches below the two small holes a slot was made. By inserting a plate in this slot the stratum between the surface of the soil and the three inches below (0-3 inch) could be secured (Fig. 13, step 3).

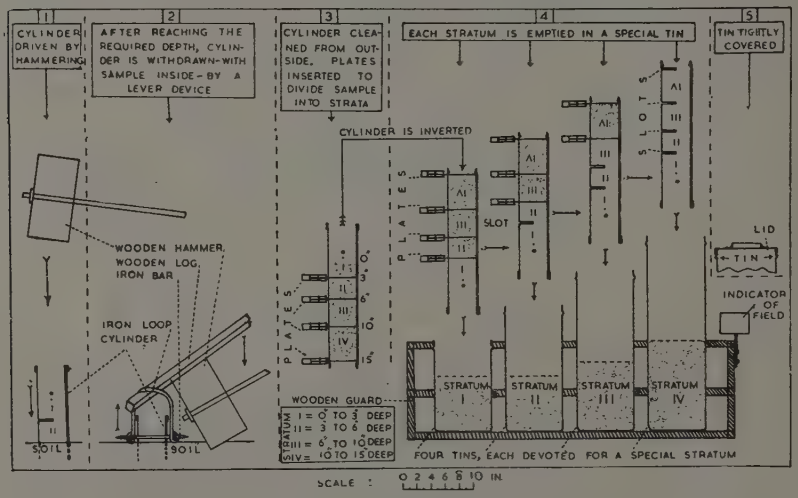

FIG. 13 : Method and steps of obtaining soil samples.

3. — The second slot was made at a distance of 3 inches below the previous one (Fig. 12), or 6 inches below the small holes and served to secure by means of plates the successive 3 - inch layer or the stratum between 3-6 inches (II).

4. — The third slot was made at a distance of 4 inches below the second, and served to secure the successive 4 - inch layer or the stratum between 6-10 inches (III) of the sample.

5. — The fourth slot was made at a distance of 5 inches below the third or at one inch from the lower edge of the tool, and it served to secure the successive 5 - inch. layer or the stratum between 10-15 inches (IV) of the sample.

The lowermost cutting part of the tool was strengthened from inside by a steal collar (Fig. 12), 2 mms. thick, firmly inserted and well soldiered to the wall of the tool. The lower end of the collar was also sharpened while the upper end was not. This collar served the dual purpose of strengthening the cutting portion of the tool and facilitating the emptying of the sample by preventing it from sticking firmly to the wall of the cylinder.

By means of four steel plates (Fig. 12) inserted in the slots as soon as the cylinder was withdrawn (Fig. 13, step 3), the cavity of the latter, now filled with the soil sample, was divided into four compartments securing the four successive strata of 3, 3, 4 and 5 inches thick respectively from the soil surface downwards (strata I, II III, and IV). The plate, made of moderately thick zinc (Fig. 12), was circular in shape with elongated portion suitably inserted in a wooden handle. Almost one half of its circumference was sharpened, serving for cutting the sample when inserted in the slot made in the cylinder.

In practice, the cylinder, devoid of the plates, was hammered into the soil (Fig. 13, step 1) until the secured soil surface reached the two smaller holes differentiating the actual sampling part of the cylinder from its accessory upper part. The cylinder was hammered right into the soil by means of a heavy wooden beetle (Figs. 12 and 13, step 1) bound with an iron loop. Care was taken to drive the cylinder as vertical as possible.

The withdrawal of the cylinder from the soil was at first a difficult and laborious task, but soon the following device was initiated and used till the work was finished. Two larger holes were made in the cylinder, each at one inch distant and at a higher level from the small hole (Fig. 12). A U-shaped iron loop with two suitable meshes, each at the free end of its arms, was prepared (Figs. 12 and 13, step 2) together with another straight bar. To withdraw the cylinder, the U-shaped loop was adjusted so that the two meshes were each contiguous to one of the larger holes from the outside. In this manner the straight bar could be easily inserted through both the mesh and the larger hole from one side and continuously driven to pass through the hole and mesh of the other side. By inserting a suitable wooden log (Fig. 13 step 2) in the loop, now attached firmly to the cylinder by the bar, and by using the hammer as an articulating axis, a lever of the first grade was then constructed with the cylinder securing the sample on one side and the human force operating on the other longer side. This plan proved to be more convenient as well as more time - and labour - saving than removing the soil around the cylinder by spading. As soon as the latter was withdrawn, any soil adhering to the outside wall of the cylinder was removed by the cleaner (Fig. 2), then the four plates were inserted in the slots (Fig. 13, step 3) for purpose of dividing the sample into the four successive strata. Each of the latter was then emptied separately into a special zinc tin divised for this purpose (Fig. 13, step 4).

In order that the cylinder could resist hammering without being deformed or the slots being closed as frequently happened at the beginning of the work,

special precautions were taken. A strong collar was soldiered around the uppermost end of the cylinder (Fig. 12). Also the half side of the wall of the cylinder not containing the slots was doubled and carefully soldered.

Most investigators treated the samples obtained singly, but COCKBILL et AL. (1945) found it more practicable to make composite samples in order to save time and labour though sacrificing the informations obtainable by single samples. The writer hand found that if he treated each layer of each sample singly, this, though prefereble, would not fit to his personal circumstances. Finally he decided to bulk the strata of similar depths obtained from the same field at each time to make composite samples. That is to say, the five random samples taken at a time from a special field were finally made to construct four composite samples each representing one of the special successive strata referred to above.

Zinc tins were used to receive the samples and to tranfer them from the field to the laboratory. For each field a set of four tins was prepared. The set of the tins was designed as follows (Fig. 13, step 4).

1. — Tin (I), 8 inches in diameter by 13 inches high, devoted for receiving and transporting the five upper surface samples, each of 3 inches thick (samples 0-3 inches) which were bulked together to form one composite sample.

2. — Tin (II), 8 inches in diameter by 18 inches high, devoted to receive and transport the five successive samples, each of 3 inches thick (samples 3-6 inches).

3. — Tin (III), 8 inches in diameter by 23 inches high, devoted to receive and transfer the five successive samples each of 4 inches thick (samples 6-10 inches).

4. — Tin (IV), 8 inches in diameter by 28 inches high, devoted to receive and transfer the five successive samples each of 5 inches thick (samples 10-15 inches).

The capacity of every tin in the set was apparently larger than the net whole volume of the samples received. The extra volume was beneficial for purpose of macerating the composite sample with water for at least 48 hours before the washing process. The height of the tins in the set varied for purpose of differentiating the tinsof special similar strata from others, and consequently for avoiding the confusion of putting any stratum erronously in a tin not devoted for receiving it. This plan facilitated the task to a great extent both during emptying the samples from the cylinder into the tins in the field or during the washing process in the laboratroy. Every set of four tins was grouped in a wooden guard (Fig. 13, step 4) or ease of carrying to the field or back to the laboratory. Before the sampling process commenced, each set was marked by a figure denoting the field from which the samples were obtained. Usually, samples were obtained from two fields at a time.

The tin was made of galvanized zinc, strong enough to withstand the task. Each tin was covered by a lid of the same material, fitted snugly against the tin wall. (Fig. 13, step 5), from which a slight projection (shown by arrows in the Figure) coinciding the lower edge of the lid assure firmness of the cover. The tins were covered as soon as the samples were obtained in the field. In the laboratory they

were lifted to add water for maceration. Finally the tins remained covered until the washing process which should start at least 48 hours later.

IV. EXTRACTION TECHNIQUE

The washing and extracting procedure described in Part II was used in the present work.

V. RESULTS AND DISCUSSION

A. Means per acre per annum

Among other insect orders obtained *Coleoptera* stood next to *Thysanura* as to the number of individuals, but it stood first as to the number of genera and species. Figure 14 shows the means of coleopterous insects per acre per annum and their percentages with regard to other soil insects. It shows that these insects constituted a good fraction of the soil insect fauna, especially in the light clay soils (fields A to D) where means were higher.

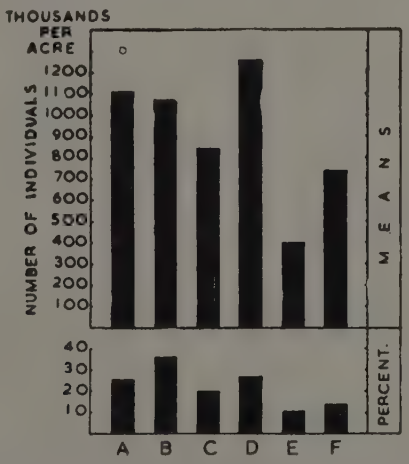

FIG. 14 : Faunal means per acre per annum, and percentages (in total insects). (A) to (F) : Fieds examined.

B. Means per acre under different rotational periods

These means are shown in Figure 15 which illustrates the following :

1. — Means under berseem (clover) were comparatively higher. This may be related to the crowded green covering as well as the comparative preservation of temperature (GRAY and NASSAR, 1928).

2. — Means under summer fallows were more or less lower than either the preceeding or succeeding crops or both. The lowest mean was met with under the dry summer fallow in field (C). This may be interpreted by the migration of beetles from the bare land to other suitable places where they can feed and oviposit.

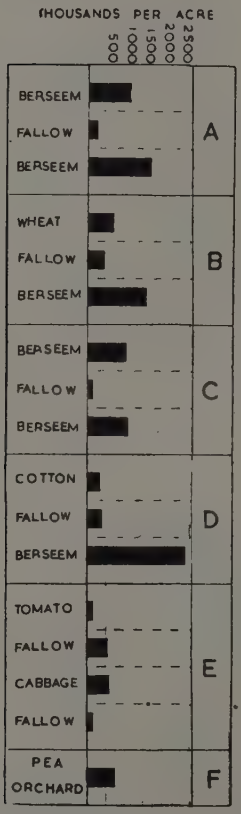

FIG. 15 : Means per acre (in thousands) under various rotational periods. — (A) to (F) : fields examined.

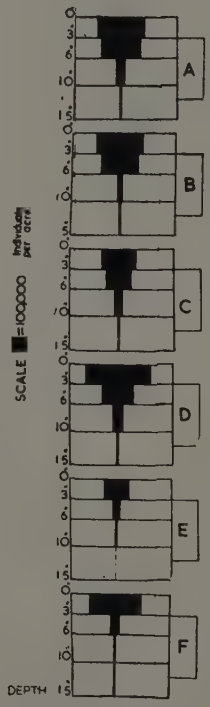

FIG. 16 : Distribution in depth. — (A) to (F) : fields examined.

3. — Concerning the means under crops, those under wheat (field B) and tomato (field E) were the lowest. This may be due to dryness and higher temperature because these crops were in their last periods of growing.

C. Distribution in depth

The distribution of Coleoptera in depth is shown in Figure 16 from which the following remarks can be given :

1. — The number of coleopterous insects decreased with the increase of depth in general.

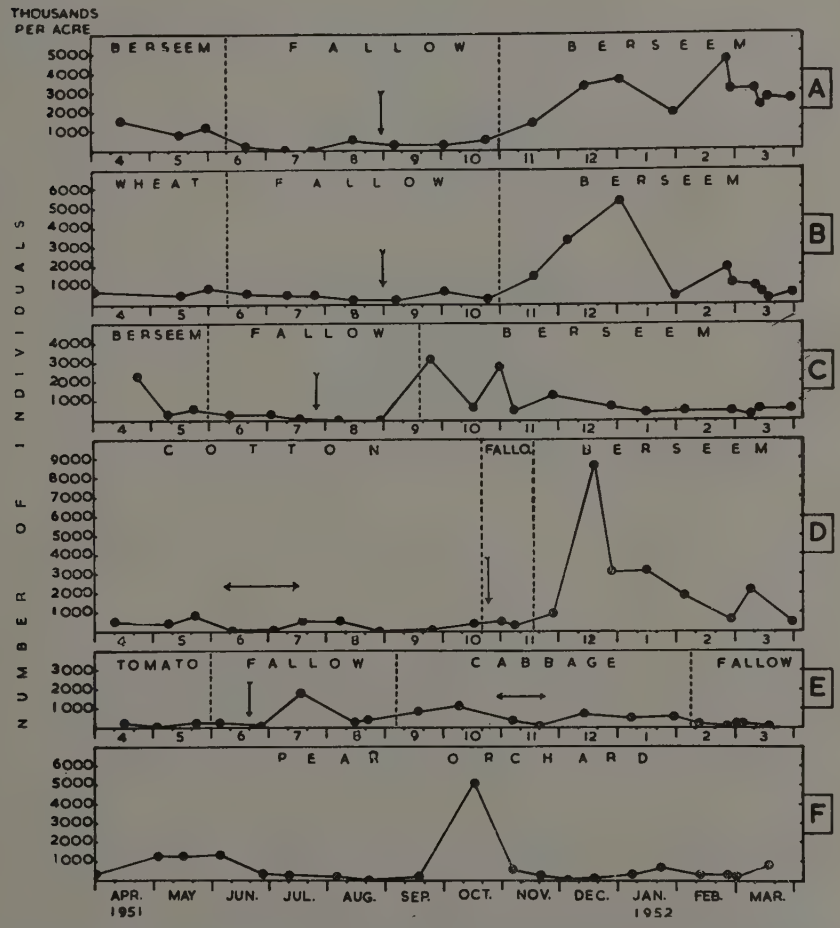

FIG. 17 : Coleopterous faunal means per acre throughout the year. — (A) to (F): fields examined. — Vertical arrows refer to dates of ploughing; horizontal arrows refer to periods of dusting.

2. — In most fields the number existing in the 3" surface layer exceeded the total number found in the three successive layers combined. The second layer (3-6")

stood next to the first one (0-3") in magnitude. This means that the upper six inches contained a much higher number than the nine inches beneath.

3. — In certain cases as when the temperature was high or the earth was dry the insects penetrated rather deeply in the soil.

D. Fluctuation of means throughout the year

Figure 17 represents the means per acre of the coleopterous individuals obtained throughout the year. From this figure the following remarks could be deducted :

1. — Coleoptera were affected by temperature and dryness which caused them either to penetrate downwards or be repelled, thus becoming scarce. This was clearly noticed under summer fallows or during August-September fallows or during August-September under cotton in field (D) where the soil was very dry due to the avoidance of irrigation by farmers.

2. — High counts were usually met with in Autumn, Winter or early Spring. These were clearly remarked under berseem in the first four fields. Thus, the green covering aided by other factors, as soil humidity, seemed to have an influence on the rise of Coleoptera. Hybernation might be also another factor as some Bruchid beetles as *Bruchidius trifolii* Motsch. were only met with during November-January. HOLMQUIST (1926 and 1931), GHABN (1951) and KAMAL (1951) referred to the selection of places for hibernation by some coleopterous beetles.

E. Means per acre per annum of coleopterous stages

Table V and (Fig. 18) illustrate the means per acre per annum of the coleopterous stages. The percentages of these stages are also shown in the Table. It is noticed that :

TABLE V

Means per acre per annum (in thousands) and percentages of Coleopterous stages.

Fields	Adults		Larvae		Pupae	
	Means	%	Mean	%	Mean	%
A	470	42.34	620	55.86	20	1.80
B	405	37.85	630	58.88	35	3.27
C	270	32.14	515	61.31	55	6.55
D	520	41.27	730	57.94	10	0.79
E	175	43.21	215	53.09	15	3.70
F	180	24.32	535	72.30	25	3.38

1. — The larval means exceeded those of the adults and pupae combined, denoting the larval relative importance. This may be due to the fact that adults move more freely and are able to take to wing at will or at any disturbance.

2. — The pupae comprised a very small fraction of the coleopterous population. Accordingly, the pupal stage seemed either to last a short period or only a small fraction of the larvae might pupate at a time, otherwise a large fraction of the pupae would be expected.

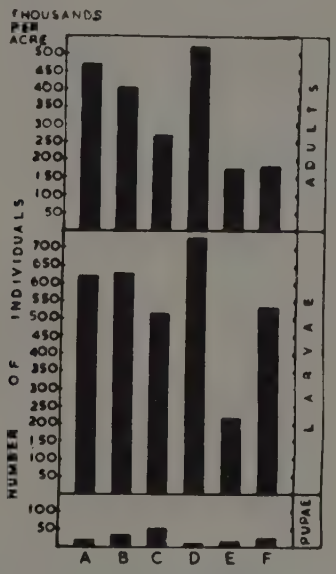

FIG. 18 : Faunal means per acre per annum of coleopterous stages. — (A) to (F) : fields examined.

F. Means per acre of coleopterous stages under various rotational periods

The means of coleopterous stages per acre under various rotational periods showed that :

1. — Pupae were very scarce or nearly absent under fallow land.

1. — The larvae exceeded the adults in number under berseem but this was not so in all cases under other crops or fallows.

G. Monthly means of coleopterous stages

1. — The number of the pupae was very scarce especially during summer in most fields.

2. — Coleopterous stages reached their maximum counts during September-January in general. In field (D) all stages reached their maxima during December while this happened during October in field (F.). Larval maximum counts were earlier than the adult maximum counts in other fields. Pupal maximum counts were

noticed to exist either during the months when larval or adult maxima occurred or during intervening months.

H. Status of Coleoptera in fields examined

The status of Coleoptera in cultivated land at Giza can be presented as follows:

1. — The total number of adults obtained were 404 individuals, besides 649 larvae and 32 pupae in the six fields examined.

2. — The adults which were the only stages indentified to species, represented seventeen families including fifty one species.

3. — STAPHYLINIDAE had an outstanding position as to both number of species and number of individuals.

4. — The prevailing species was a staphylinid beetle, *Platystethus nitens* Thoms., existing in all fields. Next to this species in importance was a scarabaeid beetle, *Pleurophorus caesus* Gr., which existed also in all fields. In 600 samples of the 4" auger, 147 individuals of the first species and 57 of the second, were obtained.

5. — Identification of larvae was difficult. The campodeiform type was the most prevailing in all months and in all fields. Wireworms were less common.

The families found are recorded hereafter according to their magnitudes (estimation of beetles only) :

1. — STAPHYLINIDAE (229) : *Platystethus nitens* Thoms. (147), *P. cornutus* Gr. (10), *P.* spec. (2), *Trogophloeus exiguus* Er. (19), *T. transversalis* Woll. (3), *T. priesneri* Koch (1), *T.* spec. (8), *Oligota* spec. (3), *Oxytelus* spec. (1), *Oxypoda apicalis* Fauv. (1), *Philonthus quisquiliarius* Gyll. (9), *Scopaeus debilis* Koch (19), *Tachyporus pusillus* Grav. (1), and *Astenus* spec. (5).

2. — SCARABAEIDAE (59) : *Pleurophorus caesus* Gr. (57), *Onthophagus sellatus* Klug (2).

3. — TENEBRIONIDAE (27) : *Ochrolamus* (*Dilamus*) *pictus* Bdi. (20), *Tribolium confusum* Duv. (5), *T. castaneum* Herbst. (2).

4. — CURCULIONIDAE (15) : *Tychius* spec. (5), *Sitophilus oryzae* L. (1), *Sitophilus granarium* L. (1), *Sitona lividipes* Fohrs. (3), *Phytonomus brunnipennis* Boh. (3), *Baris* (*Aegyptobaris*) *arctithorax* Pic (2).

5. — CARABIDAE (25) : *Tachys gilvus* Schaum. (2), *T. scutellaris aegyptiacus* Koch-Schatz. (3), *T. lucasi* Duv. (4), *T. fumigatus geminatus* Schaum (2), *T.* spec. (4), *Pterostichus barbarus* Dej. (3), *P. aegyptiacus* Tach. (2), *Bembidion niloticus* Dej. (4), *Scarites planus* Bon. (1).

6. — ANTHICIDAE (18) : *Anthicus crinitus* Lef. (7), *A. tristis* Schaum (4), *Leptaleus klugi* Laf. (7).

7. — BRUCHIDAE (12) : *Bruchidius trifolii* Motsch. (12).

8. — HYDROPHILIDAE (3) : *Ochthebius marinus meridionalis* Rey (3).

9. — PSELAPHIDAE (3) : *Pseudoplectus perplexus* J. du Val. (3).

10. — ELATERIDAE (2) : *Drasterius bimaculatus* Rossi (2).

11. — PTINIDAE (2) : *Ptinus fimicola* Desbr. (1), *Gibbium psylloides* Czemp. (1).

12. — LATHRIDIIDAE (2) : *Melanophthalma* Spec. (1), *Corticaria rutila* Motsch. (1).

13. — COCCINELLIDAE (2) : *Coccinella undecimpunctata aegyptiaca* Reiche (1), *Scymnus* (*Pullus*) *interruptus* Geoze (1).

14. — DERMESTIDAE (2) : *Anthrenops minor* Woll. (2).

15. — ORTHOPERIDAE (1) : *Anisomeristes pecirkanus* Rttr. (1).

16. — CRYPTOPHAGIDAE (1) : *Ephistemus exiguus* Er. (1).

17. — CUCUJIDAE (1) : *Laemophloeus ferrugineus* Steph. (1).

I. Summarized data

The following formulae (constructed according to MORRIS 1922 and 1927, and EDWARDS 1929) summarize most of the remarks mentioned. In each formula the capital letters (A to F) denote the fields, the arabic figures outside the brackets denote the months during which the species mentioned was met with, the first arabic figure within the brackets denotes, above, the total number of individuals obtained from the six fields and, below, in Roman numerals, the strata in which they existed. The second arabic figure within the brackets denotes, above, the maximum number met with at any one level in any field and, below, in Roman numerals, the stratum or strata where this number was found.

Species are recorded hereafter, according to their magnitudes:

Platystethus nitens Thoms., A to F, 1 to 6, 9 to 12; (147/all strata; 16/1); *Pleurophorus caesus* Gr., A to F, 1 to 12 (57/all strata; 5/III); *Ochrolamus* (*Dilamus*) *pictus* Bdi., A to E, 1,2, 4 to 7, 9 to 12 (20/all strata; 2/1); *Trogophloeus exiguus* Er., A, B, D, F, 1, 2, 11, 12, (19/I, II, III; 3/1); *Scopaeus debilis* Koch, A, C, D, E, F, 1, 2, 11, 12 (19/I, II, III; 3/1), *Bruchidius trifolii* Motsch., A, D, E, 1, 11, 12 (12/I, II III; 3/1); *Platystethus cornutus* Gr., A, B, C, D, 1, 11, 12 (10/I, II; 2/I); *Philonthus quisquiliarius* Gyll, B, D, 1, 12 (9/1, II; 2/1, II); *Trogophloeus* spec., B, C, D, 2, 11, 12; (8/1, II); *Anthicus crinitus* Laf., A, B, E, 2, 6, 7, 10, 12 (7/1, II, III); *Leptaleus klugi* Laf., A, B, F, 1, 6, 7, 10 (7/I, I,, IV) ; *Astenus* spec., A, C, D, F, 3, 4, 5 (5/1, II); *Tribolium confusum* Duv., A, B, 5, 7, 10 (5/I, II); *Tychius* spec., A, B, E, 7 to 10 (5/1, II, III); *Tachys lucasi* Duv., A, B, 1, 3, (4/1, III, IV; 2/1); *Tachys* spec., C, F, 5, 6, 12 (4/1, III, IV);

Bembidion niloticum Dej., B,C,F, 4,5,6 (4/1, II, III); *Anthicus tristis* Schaum., A, D, 1, 12 (4/1, II, IV); *Oligota* spec., A, B, D, 4, 5 (3/1, III); *Sitona lividipes* Fohrs., A, B, 1, 3, 4 (3/1, II); *Phytonomus brunnipennis* Boh., A, 1, 12 (3/I, II, III); *Tachys scutellaris aegyptiacus* Koch-Schatz., A, C, 2, 3, 11 (3/II,III); *Pterostichus barbarus* Dej., A, B, C, 5, 8, 10 (3/II); *Octhebius marinus meridionalis* Rey, B, C, 10, 11, 12 (3/I); *Pseudoplectus perplexus* J. du Val, C, E, 1, 2, 3 (3/II); *Platystethus* spec., B,

12 (2/II); *Trogophloeus transversalis* Woll., A, D, 3 (3/I,II); *Onthophagus sellatus* Klug, F, 6, 10 (2/I); *Tribolium castaneum* Herbst., B, 10 (2/I, II); *Baris* (*Aegyptobaris*) *arctithorax* Pic (Alfieri, 1936, recorded this species as injurious to *Portulaca oleraceae*, in Egypt), E, 1, 11, (2/1, III); *Tachys gilvus* Schaum., B, C, 5, 6 (2/1, III); *T. fumigatus geminatus* Schaum, B, 1 (2/11,III); *Pterostichus aegyptiacus* Tsch., B, F, 5 (2/1, IV); *Drasterius bimaculatus* Rossi, C, D, 4, 5 (2/1, IIII); *Anthrenus minor* Woll., E, F, 6, 3 (2/I); *Trogophloeus priesneri* Koch, B, 12 (1/I); *Oxytelus* spec., E., 10 (1/1); *Oxypoda apicalis* Fauv., D, 10 (1/III); *Tachyporus pusillus* Grav., D, 11 (1/1); *Sitophilus oryzae* L., D, 5, (1/1V); *S. granarius* L., B, 3 (I/III); *Scarites planus* Bon., A, 3 (1/1); *Ptinus fimicola* Desbr., E, 10 (1/I); *Gibbium psylloides* Czemp., D, 5, (1/1IV); *Melanophthalma* spec., F, 11 (1/I); *Corticaria rutila* Motsch., A, 12 (I/1); *Anisomeristes pecirkanus* Rttr., D, 10 (1/I), *Coccinella undecimpunctata aegyptiaca* Rche., A, 5 (1/1); *Scymnus* (*Pullus*) *interruptus* Goeze, D, 1 (1/1); *Ephistemus exiguus* Er., C, 5 (1/1); *Laemophloeus ferrugineus* Steph., B, I (I/IV).

Coleoptera : Adults, all fields, all months (404/all strata; 22/1).

Larvae : All fields, all months, (649/all strata; 44/1).

Pupae : All fields, 1,2,3,5,6,8,9 to 12 (32/1, II, IV; 6/1).

VI. SUMMARY

1. — A description of a sampling unit adopted for obtaining successive soil strata and a system of withdrawing it without digging around, was illustrated.

2. — The coleopterous population of six fields was treated from the following points of view : (a) means per acre per annum; (b) means per acre during different rotational periods, (c) distribution in depth, (d) fluctuation of means throughout the year, (e) means per acre per annum of coleopterous stages, (f) means per acre of coleopterous stages during various rotational periods, (g) monthly means of coleopterous stages, (h) status of Coleoptera in fields examined, (i) formulae summarising the data obtained.

VII. ACKNOWLEDGMENTS

The author wishes to express his sincerest thanks to Prof. Dr. Hamed Seleem Soliman, former Head of the Entomological Department of the Farculty of Agriculture (Cairo University), who suggested this line of work, and to Prof. Dr. Ahmed Salem Hassan, Professor of Entomology and Head of the Plant Protection Department of the Faculty of Agriculture (Cairo University), for valuable and helpful criticism in the course of this work. Thanks are due to Prof. Dr. Herman Priesner, Mr. A. Alfieri (General secretary of the Entomological Society of Egypt), Prof. Dr. Mahmoud Hafez, Dr. Salah Abul Nasr, Dr. A. I. Hassan, Prof. Dr. Mohamed Taher El-Sayed, and Prof. Dr. Wilhelm Kuhnelt of the Vienna University, for identification of the fauna mentioned in this paper.

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ON THE MOUTH PARTS OF THE LARVAL INSTARS OF *CULEX QUINQUEFASCIATUS* (SAY)

[*Diptera* : *Culicidae*]

(with 38 Text-Figures)

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CONTENTS

I. Introduction. — II. Rearing, feeding habits, and technique. — III. General morphology of the head. — IV. Mouth parts of the fourth instar larva. — V. Mouth parts of the third instar larva. — VI. Mouth parts of the second instar larva. — VII. Mouth parts of the first instar larva. — VIII. Summary of the important instar differences. — IX. Key to the larval instars.—X. Acknowledgments. — XI. Bibliography.

I. INTRODUCTION

A gross study of the morphology of the larval head of *Culex quinquefasciatus* (Say) and, a detailed comparative description of the mouth parts in all the instars, is accomplished. The homologies of the different parts of the mouth with those of a generalized insect have been thoroughly discussed in a previous work by the author on the mouth parts of *Anopheles quadrimaculatus* (Say) (SHALABY, 1956) and *Aedes aegypti* (Linn.) (this Bulletin, pages 145-177). The same nomenclature is also used. Detailed illustrations of the mouth parts in all the stages of development are provided. This enabled the writer to construct a key to the instars, based on the differences between the mouth parts of the larvae in their various stages of growth.

II. REARING, FEEDING HABITS AND TECHNIQUE

The larvae of *Culex quinquefasciatus* are not diffucult to rear in the laboratory. However, they are easily collected outdoors,.as they breed readily in semidomestic

situations, such as the water that accumulates in fish ponds, tin cans, or almost any other type of container.

The larvae in all the instars, have the filtering feeding habits. In the laboratory, the first instar larvae are transferred to special containers where they are fed on a suspension of crumbled yeast in water. Aeration is necessary for the survival of the larvae.

The larvae are killed in hot water before preservation in 70% alcohol. The specimens are transferred again to vials containing 95% alcohol. Dissection of the mouth parts is accomplished in a medium of glycerine. For permanent mounting, the specimens are cleared in beechwood creosote. After the clearing process is completed, the specimens are transferred to xylene for not more than a minute. Then they are mounted in Canada balsam and covered with a cover slip. The slide is then placed in an oven at 40 °C. for a short while, after which the specimen is ready for study.

III. GENERAL MORPHOLOGY OF THE HEAD

The head, in all the instars, is prognathus. The frons (Fig. 2, F) covers almost the entire dorsum of the head. It is bounded cephalad by the fronto-clypeal suture (FCS) and laterad by the frontal sutures. A clypeal suture divides the clypeus into a preclypeus cephalad and a postclypeus caudad. The preclypeus is wide laterad and narrow mesad. Two preclypeal hairs arise from the lateral parts of the preclypeus and extend cephalad. The lateral extremities of the clypeus extend caudad on each side of the head and widen to become invaginated inside the head forming the paraclypeal phragmata (Fig. 1, PrPh).

The labrum (Fig. 2, Lr) is located at the distal end of the head. The antennae (Fig. 1, A) are long. Each antenna is provided with a conspicuous tuft (AF) which arises from the proximal end of its distal third. Arising from the distal end of the antenna are two papilliform short processes and two relatively long and fine setae, which probably are sensory. The larval eyes (Fig. 1, LE) are located on the ocular lobes on each side of the head. Each eye is composed of two parts, a large cephalic part which is in the shape of half a circle, and a very small caudal part which is roughly oval in shape.

The submentum (SMt) occupies the meso-caudal area of the ventral aspect of the head. It is oval in shape and more pigmented than the lateral postgenae (PG). The submentum is bounded laterally by the submental-postgenal sutures (SPS). The posterior tentorial pits (PT) are situated at the distal end of the proximal third of the submental-postgenal sutures before they reach the occiput (Oc). The submentum is partially divided length-wise by the median suture (MS) which extends only a short distance cephalad. In the larva of *Anopheles quadrimaculatus* the median suture is obsolete (SHALABY). The rest of the labium (Lb) is located cephalad of the submentum. A pair of maxillae (Mx) and a pair of mandibles (Md) are located

on the sides of the ventral aspect of the head. The mandibles are located dorsad of the maxillae. The mouth opening (MO) is the space enclosed by the epipharynx (Ep) above, the hypopharynx below and, the mandibles and the maxillae forming the side walls.

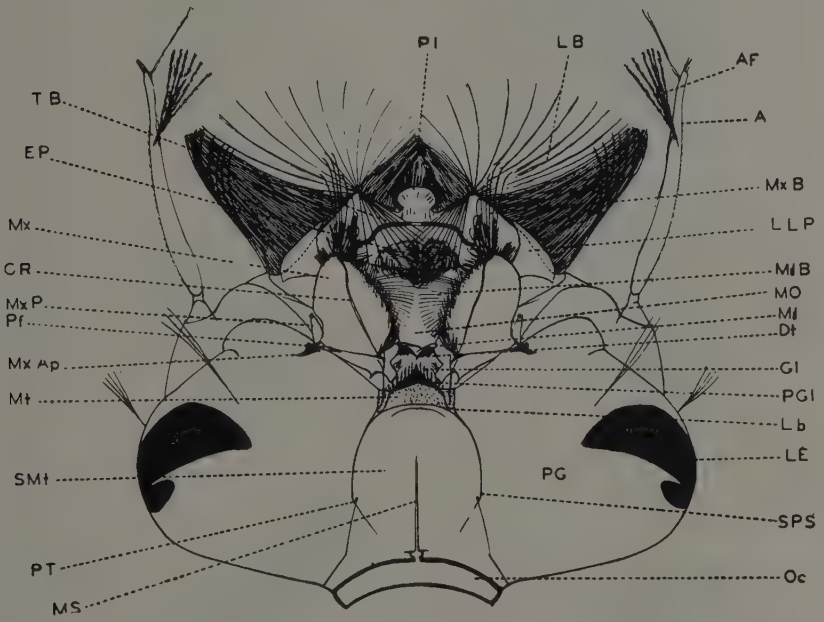
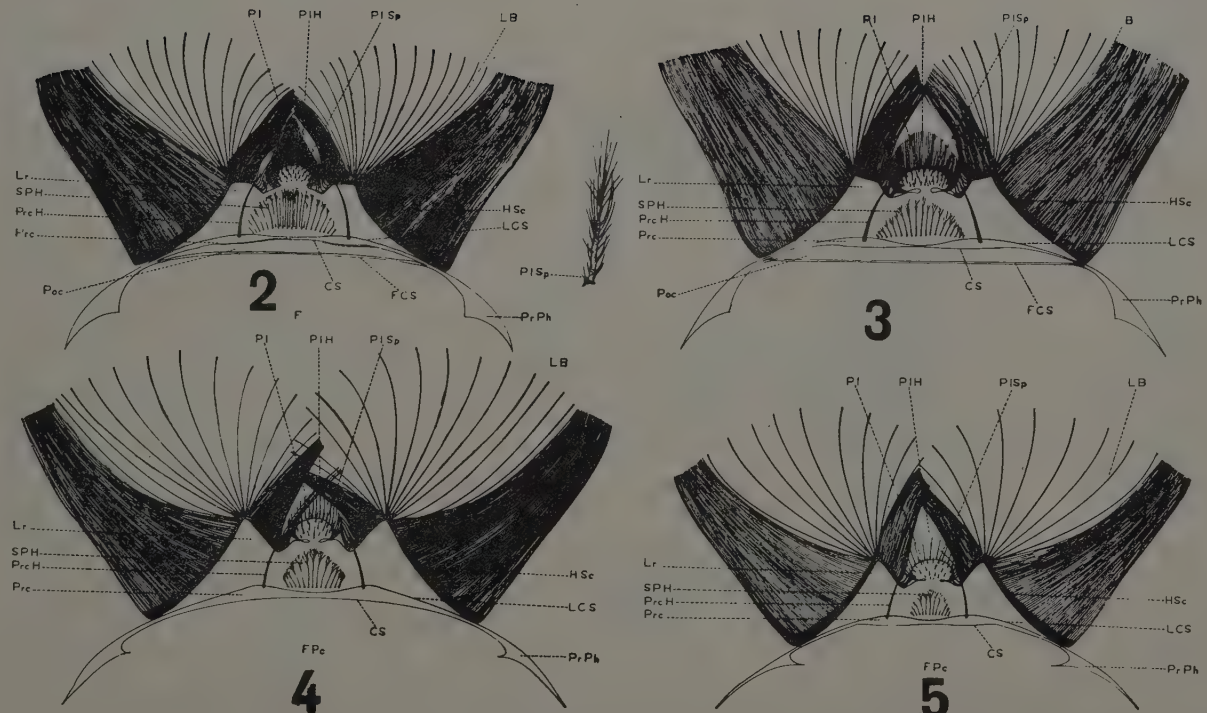


FIG. 1 : Ventral aspect of the head of the fourth instar larva.

IV. THE MOUTH PARTS OF THE FOURTH INSTAR LARVA

The head capsule in the fourth instar larva is about 1.104 mm. in width. The mouth parts are adapted for the filtering feeding habit. They consist of the labrum, the mandibles, the maxillae and the labium.

The LABRUM (Fig. 2, Lr) is located at the cephalic end of the head. It is composed of the disto-median palatum, and the two lateral labral brushes. The labrum is separated from the clypeus by the labro-clypeal suture (LCS), which is slightly concave mesad and convex laterad. The clypeus is divided by the clypeal suture (CS) into the preclypeus and the postclypeus (Prc and Poc). The postclypeus is separated from the frons (F) by a very conspicuous and pigmented fronto-clypeal suture (FCS). In the larval head of *Aedes aegypti* the fronto-clypeal suture is absent, which results in the fusion of the frons and the postclypeus forming a fronto-postclypeus (SHALABY). The preclypeal hairs (PrcH) are spine-like, heavily pigmented



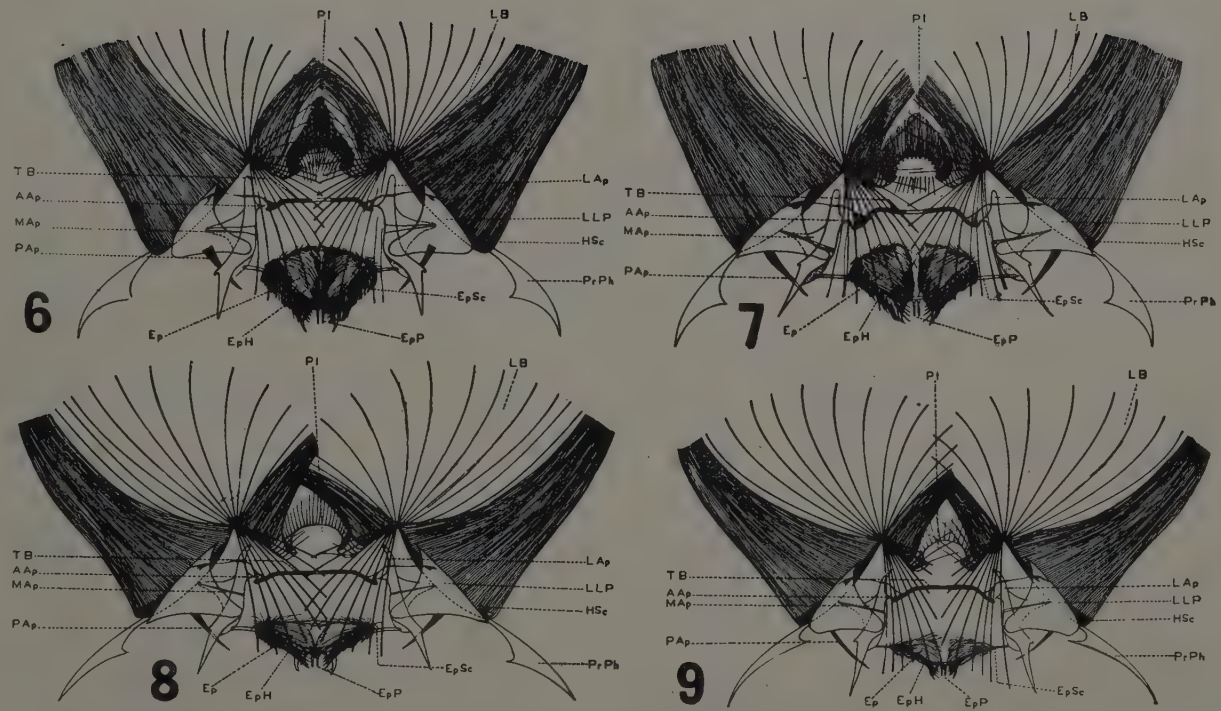
FIGS. 2-5 : Dorsal aspect of the cephalic region of the fourth, third, second, and first instar larval head, respectively.

and sclerotized. The paraclypeal phragmata (PrPh) are triangular in shape, heavily pigmented and highly sclerotized.

The PALATUM (Figs. 2 and 6, Pl) is a small roughly rounded structure. Arising from the margin of the palatum are the palatal hairs (Fig. 2, PlH). They are simple, fine and numerous. They are long mesad and shorten gradually laterad. The ectal surface of the palatum is armed with dark, pointed palatal spines (PlSp). Under high magnifications, the palatal spines are produced into short branches proximad and long branches distad. The distal end of the spine, however, divides into a great number of very fine and relatively long branches as shown in Figure 2. The ental surface of the palatum (Fig. 6, Pl) is also provided with spines which are fewer, less pigmented and slightly longer than the palatal spines. The palatum is connected with the preclypeus by means of a quadragular shaped, membranous and flexible area. The suprapalatal hairs (Fig. 2, SPH) arise from the meso-caudal region of this membranous area, and form a fan-shaped structure. In the larval head of *Anopheles quadrimaculatus* the suprapalatal hairs are lacking (SHALABY). Each of these hairs are divided distally into numerous, very fine branches.

The LABRAL BRUSHES are located laterad of the palatum. They arise from an elongated and heavily pigmented hair-bearing sclerite (Figs. 2 and 6, HSc). The hairs of the labral brush are all simple. Each labral brush is composed of four groups of hairs. The first group is borne on the entire length of the hair-bearing sclerite. The hairs of this group are dense long, simple, slightly curved and directed cephalo-laterad. The second group of hairs is located mesad of the first group. It arises from the cephalic end of the hair-bearing sclerite. It is composed of fewer curved hairs which extend cephalo-mesad. The third group of hairs is the most mesal group, and is borne on the mesal part of the hair-bearing sclerite. The hairs are finer, more dense and slightly shorter than those of the second group. The fourth group of hairs is located on the ental aspect of the labrum, as they arise from the arched part of the hair-bearing sclerite, cephalad of the labral apodeme (Fig. 6, LAp). This group is composed of fine simple hairs which extend meso-caudad to overlap with the hairs of the same group of the opposite side forming a sieve-like structure which helps in the filtering process.

The apodemes of the labral brushes (Fig. 6, LAp, LLP and TB) are located on the ental aspect of the labrum. They serve as a support for the labral brushes, as well as for muscular attachments. The labral apodemes (LAp) are sclerotized and pigmented elongated structures which extend from the cephalic end of the head to the level of the middle part of the lateral margin of the mandible when the latter is in the adducted position. The cephalic end of the labral apodeme is rounded. Each labral apodeme possesses three processes. The anterior process of the labral apodeme (AAp) is short, pointed and directed mesad. It is attached to the proximal end of the mesal margin of the distal third of the labral apodeme. The medial process of the labral apodeme (MAp) is triangular in shape and extends laterad. It is attached to the lateral margin of the medial third of the



FIGS. 6-9 : Ventral aspect of the cephalic region of the fourth, third, second, and first instar larval head, respectively.

labral apodeme. The posterior process of the apodeme (PAp) is heavily sclerotized and pigmented. It is attached to the distal end of the proximal third of the labral apodeme. The proximal third of the apodeme is pointed proximad, and bears on its disto-lateral end a small somewhat pointed protrusion which extends latero-caudad. This protrusion may be analogous to the slender short spine, arising from the same location in the labral apodeme of the larval head of *Aedes aegypti* (SHALABY). In the larval head of *A. quadrimaculatus* this protrusion is lacking (SHALABY). Attached to the disto-mesal extremity of the proximal third of the labral apodeme is a small oval shaped membranous area to which is attached the lateral extremity of the epipharyngeal sclerite (EpSc).

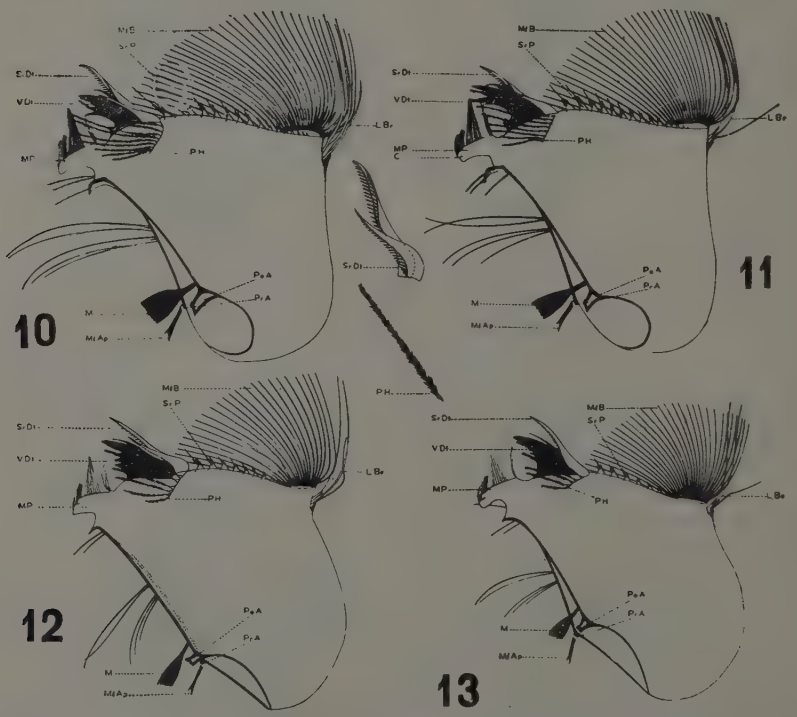
The lateral labral plate (LLp) is situated in the gap left between the labral apodeme and the hair-bearing sclerite. It is triangular in shape, slightly sclerotized and lightly pigmented, with its base partially covering the ental surface of the hair-bearing sclerite, while its mesal end lies across the median part of the labral apodeme. Unlike the labral plates of *A. quadrimaculatus* and *A. aegypti*, the lateral labral plate of *Culex quinquefasciatus* is attached at its cephalic end to the lateral extremity of the transverse bar (TB) by means of a slender wire-like sclerite which is heavily pigmented.

The transverse bar extends transversely across the ental aspect of the labrum, between the anterior processes of the labral apodemes. It is highly sclerotized and heavily pigmented. The heavily pigmented parts of the transverse bar on each side do not meet at the meson, but they are connected together mesad by means of a short slightly pigmented sclerite. The lateral extremities of the transverse bar are bent caudad and then laterad until they meet the anterior process of the labral apodemes. Arising from the lateral ends of the transverse bar are triangular-shaped, and lightly pigmented sclerites which extend cephalo-laterad. They taper distally into a heavily pigmented and flexible wire-like sclerites which extend laterad to connect with the cephalic region of the lateral labral plates. This wire-like sclerite may help in synchronizing the movement of the transverse bar and the labral plates and in turn the labral brushes.

The EPIPHARYNX (Fig. 6, Ep) is oval in shape and situated mesad between the proximal regions of the labral apodemes, on the ental surface of the labrum. It consists of the epipharyngeal sclerite (EpSc), the epipharyngeal hairs (EpH) and the epipharyngeal processes (EpP). The epipharyngeal sclerite is relatively slender, pigmented and conspicuously arched caudad at the mesal region. Its lateral extremities are connected with the membranous areas attached to the disto-mesal region of the proximal third of the labral apodeme. The epipharyngeal hairs consist entirely of simple and fine hairs. However, they can be divided into two groups, a mesal group which consists of very numerous simple hairs and a lateral group, which consists of dense hairs that overlap each other and extend caudad. There are three pairs of epipharyngeal processes which are attached to the arched mesal region of the epipharyngeal sclerite and are directed caudad. The most lateral pair is spine-like,

stouter and longer than the other two pairs. The other two pairs are papilliform in shape and with somewhat pointed ends.

The MANDIBLES (Figs. 10 and 14) are roughly quadrilateral in shape. The homologies of the different parts of the mandible with those of a generalized insect have been discussed by the author in his work on the mouth parts of *Anopheles quadrimaculatus*. The dentes-bearing area of the mandible is highly sclerotized, heavily pigmented and located at the meso-cephalic region. It bears three groups of dentes, a ventral group, a dorsal group and a serrated group. The ventral group of dentes (Figs. 10 and 14, VDt) consists of six dentes. The most cephalic tooth is spine-shaped



FIGS. 10-13 : Ventral aspect of the left mandible of the fourth, third, second, and first instar larva, respectively.

and arises from the middle of the cephalic margin of the dentes-bearing area and extends meso-cephalad. Caudad of this cephalic tooth and extending mesad are four ventral dentes which are relatively short. These four teeth vary in size and length. The sixth ventral tooth is blunt, short and arises from the meso-caudal margin of

the dentes-bearing area. The dorsal group of dentes (Fig. 14, DDt) consists of four dentes which are situated at the caudal region of the dentes-bearing area. They arise from one common base and vary in size and length.

The serrated group of dentes (Figs. 10 and 14, SrDt) consists of two dentes and arise from the ventro-lateral region of the dentes-bearing area. The writer believes that they are homologous as well as analogous with the serrated dentes in the mandible of *A. quadrimaculatus* (SHALABY). The two dentes vary in length, one is longer than the other and both are directed meso-cephalad. The longer tooth contains two rows of relatively long projections. The shorter tooth has only one row. The serrated dentes increase the crushing area of the mandible. Arising from the meso-cephalic region of the ventral aspect of the mandible caudad of the dentes-bearing area is a group of plumose hairs (Fig. 10, PH). It consists of nine spine-like and relatively long hairs which extend mesad. Under high magnifications, each plumose hair is somewhat stout proximad and tapers gradually to become pointed distad. These plumose hairs are probably analogous with the pectinate hairs which arise from the same region of the mandible of *A. aegypti* (SHALABY).

The membranous process (Figs. 10 and 14, MP) is located caudad of the dentes-bearing area. It has a convex cephalic margin, from which arise five clusters of hairs which differ in length and location. Two clusters arise from the dorsal aspect, and three clusters arise from the cephalic margin. The lateral dorsal cluster consists of numerous, fine and relatively long hairs which overlap distally and extend cephalo-laterad. The mesal dorsal cluster, consists of fewer and shorter hairs. The hairs arising from the cephalic margin are composed of three clusters, a lateral, intermediate and a mesal cluster. The lateral cluster consists of numerous long and fine hairs, which extend meso-cephalad. The intermediate cluster consists of fewer, shorter and more rigid hairs which extend cephalad. The mesal cluster is composed of finer but more numerous hairs which are slightly curved and extend cephalad. The mesal margin of the mandible is highly sclerotized and heavily pigmented along its entire length. Arising from its middle are fine, long and slightly curved hairs which extend meso-caudad. There are three plumose hairs which arise from the meso-cephalic region of the dorsal aspect of the mandible, laterad of the cephalic end of the mesal margin.

The mandible is articulated to the ventral wall of the head by means of the preartis and the postartis (Figs. 10 and 14, PrA and PoA). The articulation is strengthened by a heavily pigmented and sclerotized mandibular apodeme (MdAp). The abductor muscle (Fig. 14, M) is attached to the meso-caudal end of the mandible. The lateral margin of the mandible is more or less straight and devoid of setae or spines. At the distal end of the lateral margin is located a sclerotized socket which bears the lateral bristles (LBr). The lateral bristles are four in number, three long curved bristles which are directed cephalo-mesad, and a short mesal spine-shaped bristle.

The mandibular brush (MdB) contains a great number of setae which lie across the cephalic region of the dorsal aspect of the mandible. The most lateral

setae are long and curved. They shorten gradually and become more or less straight mesad. This brush arises from a heavily pigmented slender sclerite (Fig. 14, ScB). The cephalic margin of the mandible is produced into a number of triangular shaped and somewhat pigmented processes which are referred to as the serrated processes (Figs. 10 and 14, SrP). These processes are lacking in the mandibles of *A. quadrimaculatus* and *A. aegypti* (SHALABY). Each process is provided distally with a relatively long fine seta and a number of short setae. The writer believes that the mandibular comb of *A. aegypti* is the result of the growth of the serrated processes into long bristles froming a comb-like structure.

The MAXILLAE (Fig. 18) are located on either side of the head ventrad of the mandibles. The maxilla is oval in shape. It is composed of the galea (Ga), the lacinia (Lc), the cardostipes (CdSt), the maxillary palpus (MxP) and the palpifer (Pf). The homologies of the various lobes of the maxilla with those of a generalized insect have been discussed thoroughly by the author in his work on the mouth parts of *A. aegypti*. The mesal margin of the maxilla is prominently convex. It is clothed with a great number of spines and setae which extend cephalo-mesad. There are two or three rows of short and somewhat pigmented spines which overlap with the proximal ends of the setae thus forming a sieve-like structure. Five to seven relatively long pectinate spines (PcSp) arise near the caudal end of the mesal margin. They are long cephalad and shorten gradually caudad. The mesal region mesad of the chitinous ridge (CR) is clothed with numerous very fine hairs.

The chitinous ridge is heavily pigmented and sclerotized. It extends lengthwise along the middle of the maxilla. In the larva of *A. quadrimaculatus*, the maxilla does not possess a chitinous ridge (Shalaby). Arising directly from the middle part of the chitinous ridge are two papilliform membranous appendages (MACR). The maxilla is articulated to the ventral wall of the head capsule by means of the entoparartis and the exoparartis (Enp and Exp). The entoparartis is fused with the caudal and of the chitinous ridge. The exoparartis is situated at the caudo-lateral end of the maxillary palpus. The articulation is strengthened by the maxillary apodeme (MxAp).

The maxillary palpus (MxP) is relatively small and short. The lateral margin of the palpus is slightly sinuate. The palpus bears on its distal end six sensoria (S) which are short and papilliform. The palpifer (Pf) is triangular in shape and is situated caudo-laterad of the cardostipes and caudad of the maxillary palpus. In *A. quadrimaculatus* the palpifer is absent (SHALABY). The lateral margin of the maxilla is convex. It is provided with a group of quite distinct microspines (MSp) which range from 11 to 16 in number among different specimens. At the cephalic end of the galea arises a relatively long and pigmented maxillary spine (MxSp). Mesad of the maxillary spine and cephalad of the galea there is a cluster of short and rigid fan-shaped setae which extend cephalo-laterad.

The maxillary brush (MxB) consists of two types of hairs, simple hairs and pectinate hairs (PcH). The simple hairs are long and slender which range from 23 to 30 in number. The pectinate hairs are shorter and more slender than the simple

hairs. They are pectinate along their lateral margin. At the cephalic end of the lacinia arises a heavily pigmented spine (Sp) which extends meso-cephalad.

The LABIUM (Fig. 1, Lb) is located at the meso-caudal region of the ventral aspect of the head. The homologies of the various parts of the labium with those of a generalized insect have been discussed by the author in his work on the mouth parts of *A. quadrimaculatus*. Accordingly, the labium is composed of the submentum (Smt), mentum (Mt), glossa (Gl) and paraglossa (PGl). The submentum (SMt) is sub - rectangular in shape and is separated from the postgenae (PG) by the submental-postgenal sutures (SPS). The median suture (MS) as well as the anterior tentorial pits (PT) are quite distinct.

The mentum (Fig. 1, Mt and Fig. 22) is a narrow, more or less membranous plate, with a slightly convex cephalic margin. Its cephalic margin is produced mesally into a triangular-shaped protrusion which has a somewhat pointed end. Arising from this mesal protrusion are two relatively short spine-like setae which extend cephalad.

The glossa (Fig. 26) is located dorsad of the mentum and ventrad of the paraglossa (Fig. 1, PGl). It is a narrow plate, with a convex cephalic margin which is produced mesally, into a large pointed spine-like protrusion with wide base. The cephalic margin of the glossa bears a large number of bipectinate hairs (Fig. 26, BPH). They range from 48 to 52 with 24 to 26 bipectinate hairs on each side of the mesal line. These fringes are long mesad and shorten gradually laterad. Under higher magnifications, each of these fringes is provided with short and slender branches which extend along the entire length of its mesal margin, while they extend only a short distance proximad along its lateral margin. The equality in number of the bipectinate hairs of the two halves of the glossa and their apparent symmetry, may indicate that the glossa is the result of the fusion of two glossae at the mesal line.

The paraglossa (Fig. 1, PGl and Fig. 30) is roughly rectangular in shape, highly sclerotized and heavily pigmented. The mandibular dentes (Fig. 1, Dt) and the paraglossa form the crushing apparatus in the larval head. The paraglossa is composed of 23 teeth, 11 teeth on each side of the disto-central tooth. Three degrees of pigmentation and sclerotization are recognizable in the paraglossa. The distal and most lateral areas are highly sclerotized and heavily pigmented. The most lateral areas are highly sclerotized and heavily pigmented. The median area is less sclerotized and less pigmented. It fades gradually laterad to a lighter degree of pigmentation and sclerotization. The equality in the number of the teeth on each side of the mesal line and their apparent symmetry, also indicates that the paraglossa is the result of the fusion of two paraglossae along the mesal line, after being shifted dorsad of the glossa.

The HYPOPHARYNX (Fig. 34) forms the floor of the mouth cavity. It is heavily sclerotized, heavily pigmented and quadrangular in shape. The homologies of this structure with that of generalized insects have been discussed by the author in his work on the mouth parts of *A. quadrimaculatus* and *A. aegypti*. The disto-lateral ends of the hypopharynx are connected with the sclerotized and pigmented cibarial

bars (CB). The salivary duct (SO) opens through the meso-caudal area of the oval-shaped cephalic region of the hypopharynx. Two ear-shaped lateral lobes (L) are situated on the sides of the cephalic region. The middle region of the hypopharynx (Hyp) is more sclerotized and pigmented and is bounded laterad by two elongated, heavily pigmented structures which extend caudad until the cephalic margin of the paragnatha (Pgn). In the mesal region of this middle region are to be seen a few very slender transverse ridges which fade gradually laterad. Laterally, however, arise two longitudinal rows of microspines (MSp), which are small blunt and lightly pigmented. Two large hypopharyngeal processes (HypP) are located laterad of the boundaries of the middle region of the hypopharynx. These processes are heavily pigmented which are rounded cephalo-laterad and pointed caudad. There are two heavily pigmented mesal spines (MsSp) which are located between the cephalo-mesal ends of the paragnatha.

The paragnatha are located at the caudal region of the hypopharynx. Each paragnathus, for the purpose of description, can be divided into three regions, (a) the caudo-lateral region, (b) the intermediate region, and (c) the mesal region. (a) The caudo-lateral region includes numerous spines which are arranged into three rows (LSp) and two lateral groups. These three rows are the cephalic row, the intermediate row, and the caudal row; while the lateral groups are divided into the cephalic group and the caudal group. The cephalic row of each paragnathus consists of three large and somewhat pointed spines. The intermediate row consists of six small pointed spines and one large somewhat pointed spine. The caudal row is composed of numerous small spines. The cephalic lateral group of spines consists of four relatively large and somewhat pointed spines. The caudo-lateral group of spines is composed of three somewhat pointed spines, two small mesal spines and a large lateral one. (b) The intermediate region of the paragnathus is oval in shape, lightly sclerotized and barely pigmented. It bears two pairs of movable spines (MvSp) which are relatively short and somewhat pointed. (c) The mesal region of the paragnathus meets the other of the opposite side along the mesal line. It does not possess spines. There is a triangular shaped structure which is located between the meso-caudal ends of the paragnatha, which carries two sharply pointed spines at its cephalic end.

V. THE MOUTH PARTS OF THE THIRD INSTAR LARVA

The head capsule of this instar is about 1.071 mm. in width. The larva in this instar has the same filtering feeding habits of the fourth instar larva.

The LABRUM (Fig. 3, Lr) is composed, as in the fourth instar, of the disto-median palatum (Pl) and the disto-lateral labral brushes (Figs. 3 and 7, LB). The preclypeal hairs (PrcH) are a little shorter than those of the fourth instar. The suprapalatal hairs (Fig. 3, SPH) are less dense and shorter than those of the fourth instar. They are long mesad and shorten gradually laterad.

The PALATUM (Figs. 3 and 7, Pl) is oval in shape. The palatal hairs (Fig. 3, PlH) arising from the margin of the palatum are shorter and fewer than those of the fourth instar. They are long mesad and shorten gradually laterad. The mesal palatal hairs, however, are not much longer than the lateral ones. The palatal spines (PlSp) which arise on the ectal surface of the palatum are fewer and a little shorter than those of the fourth instar. The cntal surface of the palatum is provided also, with relatively long and lightly coloured hair-like spines, which are fewer than those of the fourth instar.

Each LABRAL BRUSH (Figs. 3 and 7, Lb) consists of four groups of hairs as in the fourth instar. However, the hairs of the labral brushes are shorter, finer and fewer than those of the fourth instar.

The APODEMES OF THE LABRAL BRUSHES are situated on the ental surface of the labrum and are five in number, equal to those of the fourth instar. The elongated labral apodeme (Fig. 7, LAp) is a little more slender and less sclerotized than that of the fourth instar. The anterior, medial and posterior processes of the labral apodeme (AAp, MAp and PAp) are present. The protrusion which extends caudo-laterad from the disto-lateral end of the proximal third of the labral apodeme is smaller than that of the fourth instar. Attached to the disto-mesal end of the proximal third of the labral apodeme is an oval-shaped membranous area as in the fourth instar.

The lateral labral plate (LLP) is smaller and less pigmented than that of the fourth instar. Its cephalic end, as well as the caudal end are pointed. The lateral labral plate of the fourth instar has only its cephalic end pointed and its caudal end rounded. The transverse bar (TB) is composed of two heavily pigmented symmetrical halves, as in the fourth instar. Connected with the lateral ends of the transverse bar are the wire-like sclerites which extend laterad to become attached to the cephalic end of the lateral labral plate on each side, as in the fourth instar.

The EPIPHARYNX (Ep) is suboval in shape. It is composed of the epipharyngeal sclerite (EpSc), the epipharyngeal hairs (EpH) and the epipharyngeal processes (EpP). The epipharyngeal sclerite is more slender, less pigmented and less arched than that of the fourth instar. The epipharyngeal hairs are similar to those of the fourth instar, with the exception of being lighter in color, fewer, and a little shorter. The three pairs of epipharyngeal processes are present, though they are more slender and less pigmented than those of the fourth instar.

The MANDIBLES (Figs. 11 and 15) are less sclerotized and less pigmented than those of the fourth instar. The dentes-bearing area contains three groups of dentes, the ventral group of dentes (Figs. 11 and 15, VDt), the dorsal group of dentes (Fig. 15, DDt) and the serrated dentes (Figs. 11 and 15, SrDt), as in the fourth instar. The ventral dentes are six in number. The dorsal dentes are four in number and are smaller than those of the fourth instar. The serrated dentes are two in number and are more slender and shorter than those of the fourth instar. The plumose hairs (Fig. 11, PH) are eight in number while those of the fourth instar are nine in number.

The membranous process (Figs. 11 and 15, MP) is a little shorter than that

of the fourth instar. Its mesal margin is clefted (Fig. 11, C), while that of the fourth instar is not. The five groups of hairs which arise from the membranous process are present. However, they consist of fewer, finer and shorter hairs than those of the fourth instar. The mesal margin of the mandible is heavily sclerotized and pigmented along its entire length. There are five long simple hairs which arise from the middle part of the mesal margin and extend meso-caudad. The three plumose hairs which arise from the meso-cephalic region of the dorsal aspect of the mandible are more slender than those of the fourth instar.

The mandible is articulated to the ventral wall of the head by means of the preartis and the postartis (Figs. 11 and 15, PrA and PoA). The articulation is strengthened by the mandibular apodeme (MdAp). The abductor muscle (M) is attached to the meso-caudal end of the mandible. The lateral margin ends distad into the sclerotized socket which bears the lateral bristles (LBr). The lateral bristles are three in number, while in the fourth instar there are four bristles. The most mesal short spine-like bristle which occurs in the fourth instar, is absent here.

The mandibular brush (MdB) arises from a heavily pigmented sclerite (Fig. 15, ScB) and it consists of a fewer number of hairs. The serrated processes (Figs. 11 and 15, SrP) which arise from the cephalic margin of the mandible range from 14 to 17, while those of the fourth instar range from 16 to 20. Each of these processes is provided distally with a relatively long median seta and a number of short, fine setae which are fewer than those of the fourth instar.

The MAXILLAE (Fig. 19) are smaller in size, less sclerotized and less pigmented than those of the fourth instar. The setae and spines which arise from the mesal margin of the maxilla are fewer and a little shorter than those of the fourth instar. The pectinate spines (PcSp) which arise from the caudal region of the mesal margin are four in number, while those of the fourth instar are five spines. The cluster of fine hairs, arising from the meso-caudal region of the cardostipes (CdSt), consists of a fewer and finer hairs. The chitinous ridge (CR) is slightly sinuate, sclerotized and pigmented. The two membranous appendages of the chitinous ridge (MACR) are shorter and more slender than those of the fourth instar.

The maxilla is articulated to the ventral wall of the head capsule by means of the entoparartis and the exoparartis (Enp and Exp). The articulation is strengthened by the maxillary apodeme (MxAp). The maxillary palpus (MxP) is shorter, less pigmented and its lateral margin is less sinuate than that of the fourth instar. The sensoria (S) are short, papilliform and five in number. In the fourth instar there are six sensoria. The palpifer (Pf) is comparatively small and slightly pigmented The convex lateral margin is provided with 11 to 13 microspines (MSp), while those of the fourth instar range from 12 to 15 microspines. The maxillary spine (MxSp) which arises from the cephalic region of the galea (Ga) is a little shorter and more slender than that of the fourth instar. The cluster of hairs which arises from the cephalic margin of the galea consists of comparatively finer and shorter hairs. The maxillary brush (MxB) consists of simple, as well as pectinate hairs (PcH). The

simple hairs of the brush are long and slender and range from 19 to 23 hairs, while those of the fourth instar range from 23 to 28 hairs. The pectinate hairs are comparatively short and few. The spine (Sp) which arises from the distal end of the lacinia (Lc) is comparatively short and slender, and extends meso-cephalad.

The LABIUM is composed of the submentum, mentum, glossa and paraglossa. There is no illustration here for the submentum because of its similarity to the submentum of the fourth instar, except in being smaller in size.

The mentum (Fig. 23) is narrow, slightly sclerotized and lightly pigmented. The cephalic margin of the mentum is convex. Its mesal region is produced into a triangular shaped process which is considerably shorter, less pigmented and with a wider base than that of the fourth instar. The two spine-like setae which arise from the lateral margins of this projection in the fourth instar, are absent here.

The glossa (Fig. 27) is lightly sclerotized and slightly pigmented. Its cephalic margin is fringed with bipectinate hairs (BPH) which are equal in number to those of the fourth instar. The mesal region of the cephalic margin is also produced into a triangular-shaped protrusion with a pointed distal end. The protrusion is smaller and lighter in colour than that of the fourth instar.

The paraglossa (Fig. 31) is roughly triangular in shape. It is smaller, less sclerotized and less pigmented than that of the fourth instar. The paraglossa consists of 24 teeth, 11 teeth on the left side, 12 teeth on the right side and a single disto-central tooth. The disto-central tooth is relatively small and sharply pointed, while that of the fourth instar is large and somewhat pointed. The highly sclerotized and pigmented lateral areas of the paraglossa are comparatively narrow, while the median less pigmented area is relatively large. This median area fades gradually caudad into a lighter degree of pigmentation.

The HYPOPHARYNX (Fig. 35) is smaller in size, less sclerotized and less pigmented than that of the fourth instar. The cephalic area of the hypopharynx is comparatively narrow, with the salivary duct (SO) opening at its meso-caudal region. The ear-shaped lateral lobes (L) are slightly smaller than those of the fourth instar. The median region of the hypopharynx (Hyp) is provided mesally with transverse ridges which are less conspicuous and fewer than those of the fourth instar. The two rows of microspines (MSp) are comparatively fewer, less pigmented and less conspicuous. The two hypopharyngeal processes (HypP) are slightly smaller than those of the fourth instar. There is only one highly sclerotized mesal spine (MsSp), while there are two in the fourth instar.

The paragnatha (Pgn) are located at the caudal region of the hypopharynx. As in the fourth instar, each paragnathus can be divided into (a) the caudo-lateral region, (b) the intermediate region, and (c) the mesal region. (a) The caudo-lateral region contains three rows of lateral spines (LSp), the cephalic row, the intermediate row and the caudal row, besides the two caudo-lateral groups. The cephalic and the intermediate rows of lateral spines consist of the same number of spines as in the fourth instar. The caudal row, however, is composed of much smaller and more

numerous spines than in the fourth instar. The cephalic group of spines, is composed of two spines on each side. The caudal group is composed of three spines on the left side and two spines on the right side. (b) The intermediate region of the paragnathus is lightly pigmented and possesses two pairs of papilliform and somewhat pointed movable spines (MvSp), as in the fourth instar. (c) The mesal region of each paragnathus contains a small, blunt spine, though, the mesal region of the paragnatha in the fourth instar do not possess spines. The triangular shaped structure which projects in between the meso-caudal regions of the paragnatha, is produced distally into three small and sharply pointed spines.

VI. THE MOUTH PARTS OF THE SECOND INSTAR LARVA

The head capsule of the second instar larva is about 0.536 mm. in width. There are no pronounced changes in the general arrangement of the sclerites of the head. The larva in this instar has the same filtering feeding habits as in the third and fourth instars.

The LABRUM (Fig. 4, Lr) is composed of the disto-median palatum and the disto-lateral labral brushes. It is noticed that the fronto-clypeal suture is absent in this instar. This results in the fusion of the postclypeus and the frons forming the fronto-postclypeus (FPc). The preclypeal hairs (PrcH) are a little shorter, more slender and more flexible than those of the third and fourth instars. The paraclypeal phragmata (Figs. 4 and 8, PrPh) are comparatively small and lightly pigmented. The suprapalatal hairs (Fig. 4, SPH) are much fewer, shorter and more slender than those of the third and fourth instars.

The PALATUM (Figs. 4 and 8, Pl) is comparatively small in size. The palatal hairs (Fig. 4, PlH) are much fewer, lighter coloured and finer than those of the third instar. The hair-like spin s which arise on the ental surface of the palatum of the third and fourth instars, are absent here.

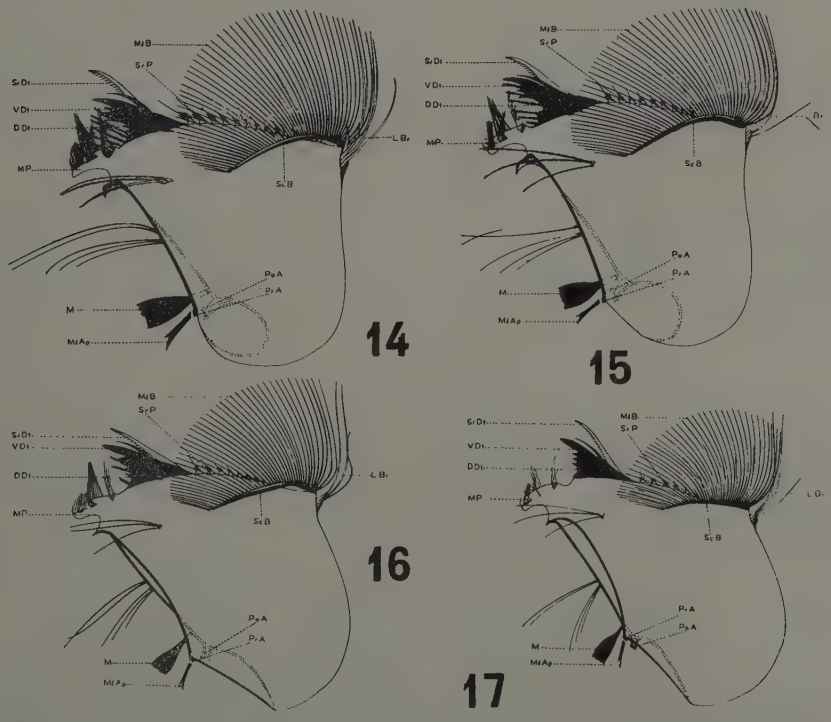
The LABRAL BRUSHES (Figs. 4 and 8, LB) are proportionally longer than those of the advanced instars. They consist of fewer and lighter-coloured hairs than those of the third instar. Each labral brush consists of four groups of hairs as in the third and fourth instars. The hairs are fewer and finer though a little longer than those of the advanced instars.

The APODEMES OF THE LABRAL BRUSHES are less sclerotized and less pigmented than those of the third and fourth instars. The labral apodeme (Fig. 8, LAp) is comparatively small in size. Its somewhat pointed distal end bends meso-cephalad, while that of the third and fourth instars is not bent. The anterior, medial and posterior processes of the labral apodeme (AAp, MAp and PAp) are present, though they are shorter and more slender than those of the advanced instars. The small projection which is attached to the disto-lateral end of the proximal third of the labral apodeme is less prominent. Connected with the disto-mesal end of the proximal

third of the labral apodeme, is the oval-shaped membranous area which is smaller than that of the third instar.

The lateral labral plate (LLP) is triangular in shape, less sclerotized and less pigmented than that of the third instar. Its cephalic and caudal ends are pointed. The transverse bar (TB) is slightly pigmented and lightly sclerotized. The two heavily pigmented symmetrical halves are connected mesad with a lightly pigmented sclerite. Attached to the lateral extremities of the transverse bar are the wire - like sclerites which extend laterad to become attached to the cephalic region of the lateral labral plate on each side.

The EPIPHARYNX (Ep) is smaller in size and lighter coloured than that of the third instar. It is triangular in shape, while those of the third and fourth instars are oval in shape. As in the advanced instars, it is composed of the epipharyngeal sclerite (EpSc), the epipharyngeal hairs (EpH) and the epipharyngeal processes (EpP). The epipharyngeal sclerite is less pigmented and relatively shorter than that of the third instar. The epipharyngeal hairs are comparatively few, fine and lightly coloured. The three pairs of epipharyngeal processes are small and lightly pigmented.



FIGS. 14-17 : Dorsal aspect of the right mandible of the fourth, third, second, and first instar larva, respectively.

The MANDIBLES (Figs. 12 and 16) are smaller in size, less sclerotized and less pigmented than those of the third and fourth instars. The ventral group of dentes (VDt) is composed of five dentes only. The serrated group of dentes (SrDt) is composed of two serrated teeth. Each tooth has one row of slender, short projections along its mesal margin, while the longer tooth of the serrated dentes in the third and fourth instars has two rows of these projections along its mesal margin. The dorsal group of dentes (Fig. 16, DDt) is composed of four dentes which are comparatively small. The plumose hairs (Fig. 12, PH) are six in number.

The membranous process (Figs. 12 and 16, MP) is short and bears five groups of hairs. These hairs are much finer and fewer than those of the third instar. The mesal margin of the mandible is pigmented and sclerotized along its entire length. Arising from its middle region are five hairs which extend meso-caudad. The three setae which arise from the meso-cephalic region of the dorsal aspect of the mandible, laterad o the distal end of the mesal margin are short and simple. Those of the third and fourth instars are long and plumose. The mandible is articulated to the ventral wall of the head by means of the preartis and the postartis (PrA and PoA). The articulation is strengthened by the mandibular apodeme (MdAp). The lateral margin of the mandible is convex, while in the third and fourth instars it is more or less straight. The lateral margin ends distad into the sclerotized and pigmented socket which bears the lateral bristles (LBr). The lateral bristles are three is number.

The mandibular brush (MdB) is considerably smaller and contains fewer setae than that of the third and fourth instars. The setae which arise from a heavily pigmented sclerite (Fig. 16, ScB) are less curved, shorter and finer than those of the advanced instars. The serrated processes (Figs. 12 and 16, SrP) which arise from the cephalic margin of the mandible are small in size and range from nine to twelve in number. Each process is provided distally with a relatively long spine-like seta and a number of short fine hairs.

The MAXILLA (Fig. 20) is comparatively small and consists of the same parts of the advanced instars. The convex mesal margin is provided with a great number of spines and setae, which are relatively short, less dense and lightly coloured. It must be noticed that the pectinate spines which arise from the caudal region of the mesal margin of the maxillae of the third and fourth instars, are here absent. The group of very fine hairs which occurs in the meso-caudal region, are considerably fewer and finer than those of the third instar. The chitinous ridge (CR) is slightly sinuate and relatively slender. The two membranous appendages of the chitinous ridge (MACR) are more slender and shorter than those of the third and fourth instars.

The maxilla is articulated to the ventral wall of the head by means of the entoparartis and the exoparartis (Enp and Exp). The articulation is strengthened by the maxillary apodeme (MxAp), which is less sclerotized and less pigmented than that of the advanced instars. The maxillary palpus (MxP) is shorter and more slender than that of the third instar. The sensoria (S) at the distal end of the palpus are four in

number only. The palpifer (Pf) is comparatively small and slightly sclerotized. The microspines (MSp) which arise from the slightly convex lateral margin range from seven to ten in number. The maxillary spine. (MxSp) which is attached to the cephalic region of the galea (Ga) is less sclerotized and more slender than that of the third and fourth instars. The cluster of hairs which arises from the cephalic margin of the galea consists of fewer, shorter and finer hairs than that of the third instar.

The maxillary brush (MxB) is smaller and less dense than that of the advanced instars. The brush is composed of simple as well as pectinate hairs (PcH). The simple hairs of the brush range from 14 to 19 hairs. The pectinate hairs are short, and range from four to five in number. The spine which arises from the cephalic end of the lacinia in the third and fourth instars, is absent in the second instar.

The labium is composed of the submentum, mentum, glossa and paraglossa, similar to that of the third and fourth instars. The submentum is oval in shape and smaller in size than that of the third instar.

The mentum (Fig. 24) is narrower, smaller in size, and less pigmented than that of the third instar. The convex cephalic margin is produced mesally into a short, small triangular shaped projection which is short and with a comparatively narrow base. The two spine-like setae which arise from the lateral margins of the projection in the fourth instar, are absent in the second instar also.

The glossa (Fig. 28) is narrower, smaller in size, less sclerotized and less pigmented than that of the third instar. Its cephalic margin is produced mesad into a triangular shaped and pointed projection. The cephalic margin is also produced into a fewer number of fringes which are composed of branched bipectinate hairs (BPH), while those of the third and fourth instars are unbranched. Each bipectinate hair possesses at least one or two branches which are simple and not bipectinate. The most mesal pair of the bipectinate hairs is unbranched. The bipectinate hairs range from 34 to 44, with 17 to 22 branched bipectinate hairs on each side of the meson.

The paraglossa (Fig. 32) is roughly quadrangular in shape. It is smaller in size, less scl rotiz d and less pigmented than that of the third and fourth instars. It is composed of 19 teeth, nine teeth on each side of the disto-c ntral tooth. The heavily pigmented area which carries the teeth is narrower than that of the third and fourth instars. The median less pigmented area is larger than that of the advanced instars. The median less pigmented area is larger than that of the advanced instars. The caudal area is comparatively lighter in colour.

The HYPOPHARYNX (Fig. 36) is comparatively small. The cibarial bars (CB) are slender and lightly pigmented. The lightly pigmented cephalic area of the hypopharynx is proportionally wider than that of the third instar. The salivary dues (SO) opens at the meso-caudal region of the cephalic area. The lateral lobes (L) are proportionally wider than those of the advanced instars. The median region of the hypopharynx (Hyp) is smaller in size and less pigmented than that of the third

and fourth instars. The mesal transverse ridges which occur in the third and fourth instars are not apparent here. The lateral heavily pigmented boundaries of the median region are comparatively short and slender. The hypopharyngeal processes (HypP) are smaller and less pigmented than those of the advanced instars. It should be noticed that the microspines which occur in the third and fourth instars (Figs. 34 and 35, MSp) are absent here.

The paragnatha (Fig. 36, Pgn) are slightly sclerotized and lightly pigmented. Each paragnathus is divided into (a) the caudo-lateral region, (b) the intermediate region and (c) the mesal region. The caudo-lateral region consists of three rows of lateral spines (LSp) and a caudo-lateral group of spines. The cephalic row of spines is composed of three sharply pointed spines which are smaller than those of the third instar. The intermediate row consists of five spines and a small detached spine. The caudal row consists of numerous small spines. There is only one caudo-lateral group of spines which consists of two spines only. (b) The intermediate region is very lightly pigmented and bears two pairs of movable spines (MvSp) which are more slender and a little shorter than those of the third and fourth instars. (c) The two mesal regions of the paragnatha fuse with each other along the mesal line, and bear two somewhat pointed spines, similar to those of the third instar. The oval-shaped structure which is located between the meso-caudal regions of the pragnatha, is considerably small, and bears only one blunt spine at its distal end.

VII. THE MOUTH PARTS OF THE FIRST INSTAR LARVA

The head capsule of the first instar larva is about 0.468 mm. in width. There is no change, whatsoever, in the general arrangement of the head sclerites. The main difference is the presence of the egg bruster (Fig. 38, EB) in the middle of the frons. The larva in this instar, has the same filtering feeding habit of the second, third and fourth instars.

The LABRUM (Fig. 5, Lr) is smaller in size than that of the second instar. The fronto-clypeal suture is absent, which results in the fusion of the postclypeus and the frons forming the fronto-postclypeus (FPc). The preclypeal hairs (PrcH) are short slender and very lightly pigmented. The paraclypeal phragmata (Figs. 5 and 9, PrPh) are comparatively small and slightly sclerotized.

The egg burster (Fig. 38, EB) is located in the middle of the frons. It is less conspicuous, if compared with those of *Anopheles quadrimaculatus* and *Aedes aegypti* (SHALABY). The egg bruster is composed of a small, circular and membranous area with a conspicuous dark spine in the center. It helps to break the chorion of the egg during the hatching process.

The PALATUM (Fig. 5, Pl) is smaller than that of the second instar. The supra-palatal hairs (SPH) are fewer, shorter, finer and lighter coloured than those of the advanced instars. The palatal hairs (PlH) are comparatively few and fine. The palatal hairs (PlH) are comparatively few and fine. The palatal spines (PlSp) which arise

on the ectal surface of the palatum are considerably few and short. The spine-like setae which arise on the ental surface of the palatum in the third and fourth instars are absent in the second as well as in the first instars.

The LABRAL BRUSHES (Figs. 5 and 9, LB) contain fewer and finer hairs than those of the advanced instars. As in the older instars, each labral brush consists of four groups of hairs. The hairs of the fourth group do not overlap with the hairs of the opposite side along the meson.

c) The APODEMES OF THE LABRAL BRUSHES are smaller in size, less sclerotized and less pigmented than those of the older instars. The elongated labral apodeme (Fig. 9, LAp) has its distal end bent meso-cephalad, similar to that of the second instar and differing from those of the third and fourth instars. The anterior, medial and posterior processes of the labral apodeme (AAp, MAp and PAp) are present, though they are short and very lightly pigmented. The protrusion which is attached to the disto-lateral end of the proximal third of the labral apodeme is very small. The oval shaped area which is attached to the disto-mesal end of the proximal third of the labral apodeme is smaller and lighter in colour than that of the second instar. The lateral labral plate (LLP) is smaller in size, less sclerotized and less pigmented than that of the second instar. The cephalic end of the labral plate is pointed, while its caudal end is rounded, as in the fourth instar. The transverse bar (TB) is shorter less sclerotized and less pigmented than that in the older instars. The two symmetrical halves of the transverse bar are connected mesad by a slightly pigmented sclerite. The lateral ends of the transverse bar are connected with the cephalic regions of the lateral labral plates on both sides, by means of the wire-like sclerites which are more slender than those of the older instars.

The EPIPHARYNX (Ep) is triangular in shape. It consists of the epipharyngeal sclerite (EpSc), the epipharyngeal hairs (EpH) and the epipharyngeal processes (EpP). The epipharyngeal sclerite is comparatively very slender. The epipharyngeal hairs are fewer, shorter and finer than those of the older instars. The three pairs of epipharyngeal processes are present, though they are very short and slender.

The MANDIBLES (Figs. 13 and 17) are small in size, slightly sclerotized and lightly pigmented. The ventral group of dentes (VDt) is composed of five teeth. The dorsal dentes (Fig. 17, DDt) are four in number, though they are very small and slender. The serrated dentes (Figs. 13 and 17, SrDt) consist of one serrated tooth only, which is relatively long and contains one row of serrations along its mesal margin. The plumose hairs (Fig. 13, PH) are five in number, while in the second instar there are six. In the third instar there are eight and in the fourth instar there are nine.

The membranous process (Figs. 13 and 17, MP) is lighter-coloured than those of the older instars. Its mesal margin is slightly cleft. The five clusters of hairs which arise from the membranous process are composed of much fewer, shorter and finer hairs than those of the older instars. The mesal margin of the mandible is sclerotized and pigmented along its entire length. The five hairs which arise from the middle of the mesal margin are short and fine. The three hairs which arise from

the mesal region of the dorsal aspect of the mandible, laterad of the cephalic end of the mesal margin are simple and not plumose.

The mandible is articulated to the head capsule by means of the preartis and the postartis (PrA and PoA), as in the older instars. The mandibular apodeme (MdAp) is comparatively short and slender. The lateral margin of the mandible is more convex than in the second instar. At its distal end, the sclerotized socket bears the lateral bristles (LBr), which are three in number. They are, however, finer, more slender and a little shorter than those of the second instar. The mandibular brush (MdB) is small. The hairs of the brush are few, short and slightly curved They arise on a sclerite (Fig. 17, ScB) which is slender and less pigmented than those of the older instars. The triangular shaped serrated processes (Figs. 13 and 17, SrP) are small, and range from 9 to 12 in number. Each process is produced distally into a relatively long spine and a number of fine hairs which are fewer and shorter than those of the advanced instars.

The MAXILLAE (Fig. 21) are smaller in size, less pigmented and less sclerotized than those of the older instars. The convex mesal margin of the maxilla is provided with numerous hairs and spines which are comparatively few, fine and lightly coloured. The pectinate spines which arise from the caudal region of the mesal margin of the maxilla of the third and fourth instars are here absent, as well as in the second instar. The chitinous ridge (CR) is slightly sinuate, lightly pigmented. The two membranous appendages of the chitinous ridge (MACR) are present, but short and slender. The maxilla is articulated to the ventral wall of the head by means of the entoparartis and the exoparartis (Enp and Exp). The maxillary apodeme (MxAp) is slightly sclerotized and pigmented. The maxillary palpus (MxP) is small. It is provided distad with four sensoria (S), equal to those of the second instar. The palpifer (Pf) is comparatively small and lightly pigmented. The slightly convex lateral margin is provided with a few lightly pigmented microspines (MSp), which range from five to seven in number. The maxillary spine (MxSp) which arises from the cephalic region of the galea (Ga) is slender and short. The cluster of hairs which arises from the cephalic margin of the galea consists of a very few hairs.

The maxillary brush (MxB) consists of simple and pectinate hairs (PcH). The simple hairs are short, lightly coloured and range from 11 to 15 in number. The pectinate hairs are considerably shorter, fewer and lighter coloured than those in the second instar. There are three or four pectinate hairs. The spine which arises from the cephalic region of the lacinia in the third and fourth instars is absent here, as well as in the second instar.

The LABIUM is composed of the submentum, mentum, glossa and paraglossa. The submentum is much smaller than that of the second instar, and is very lightly sclerotized and pigmented.

The mentum (Fig. 25) is small and more or less membranous. The cephalic margin is slightly convex. The meso-cephalic triangular projection which occurs in the mentum of the second, third and fourth instars, is absent here.

The glossa (Fig. 29) is narrower, less sclerotized and less pigmented than in the advanced instars. The triangular-shaped projection which arises from the mesal region of the convex cephalic margin of the glossa is comparatively short and small. The cephalic margin is provided with short fringes which range from 22 to 26 branched bipectinate hairs (BPH), with 11 to 13 bipectinate hairs on each side of the mesal line. It should be noticed that each bipectinate hair contains at least three branches, while that of the second instar has not more than two branches, and those of the third and fourth instars are unbranched.

The paraglossa (Fig. 33) is smaller in size, less sclerotized and less pigmented than in the older instars. It is roughly triangular in shape. The paraglossa, here is asymmetrical, as its right half is larger in size than the left half, which is a unique case. It is composed of 18 teeth, eight teeth on the left side, nine teeth on the right side and a disto-central tooth. The lateral sclerotized areas which bear the teeth are slightly sclerotized and pigmented. The median area is also slightly pigmented. The caudal area is either fused with the median area or lacking.

The HYPOPHARYNX (Fig. 37) is comparatively small. The cephalic area of the hypopharynx is more or less membranous and roughly narrower than that of the second instar. The salivary duct (SO) opens in the meso-caudal region of the cephalic area. The ear-shaped lateral lobes (L) are comparatively small. The median area of the hypopharynx (Hyp) is small and simple. The transverse ridges and the microspines which occur in the median region of the hypopharynx of the third and fourth instars, are absent in the first instar. The hypopharyngeal processes (HypP) are very small. There is only one mesal spine (MsSp).

The paragnatha (Pgn) are smaller in size, less sclerotized and less pigmented than those of the older instars. As in the older instars, each paragnathus is divided into (a) the caudo-lateral region, (b) the intermediate region, and (c) the mesal region, besides the lateral group of spines at the extreme caudo-lateral end. The cephalic row of lateral spines (LSp) of the caudo-lateral region consists of three spines, the intermediate row consists of five small spines and the caudal row consists of numerous microspines. The caudo-lateral group of spines consists of two spines only as in the second instar. The intermediate region of the paragnathus is small, membranous and bears two pairs of movable spines (MvSp). The mesal region of the paragnathus fuses with that of the opposite side and contains one small blunt spine, similar to that of the second instar. The oval shaped area which projects between the meso-caudal regions of the paragnatha is small and contains no spines at its distal end, differing from those of the second, third and fourth instars.

VIII. SUMMARY OF THE IMPORTANT INSTAR DIFFERENCES

Due to the great similarity in the mouth parts of the different instars, the writer thinks it is advisable to note the most pronounced differences and trace them through the first, second, third and fourth instars.

The egg burster (Fig. 38, EB) is present in the first instar only.

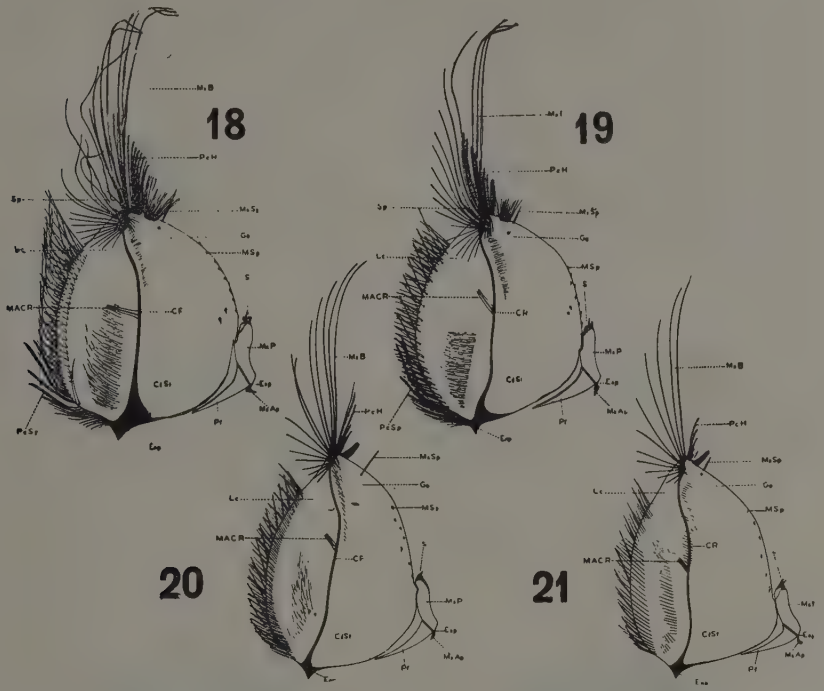
The postclypeus in the first instar is fused with the frons, forming the fronto-postclypeus (Fig. 5, FPc) due to the absence of the fronto-clypeal suture, as in the second instar. In the third and fourth instars, the postclypeus in (Figs. 2 and 3, Poc) is separated from the frons (F) by the fronto-clypeal suture

The ventral dentes in the mandible of the first instar (Figs. 13 and 17, VDt) are five in number as in the second instar. The ventral dentes in the third and fourth instars (Figs. 10 and 11, VDt) are six in number. There is only one serrated dent in the mandible of the first instar (Figs. 13 and 17, SrDt) which bears only one row of serrations. The serrated dentes of the second, third and fourth instars are composed of two serrated dentes; the longer of which bears two rows of serrations along the mesal margin. The serrated processes which arise from the cephalic margin of the mandible of the first instar (SrP) range from five to nine, while those of the second instar (Figs. 12 and 16, SrP) range from 9 to 12. The serrated processes of the mandible of the third instar (Figs. 11 and 15, SrP) range from 14 to 17, while in the fourth instar (Figs. 10 and 14, SrP) there are more than 17.

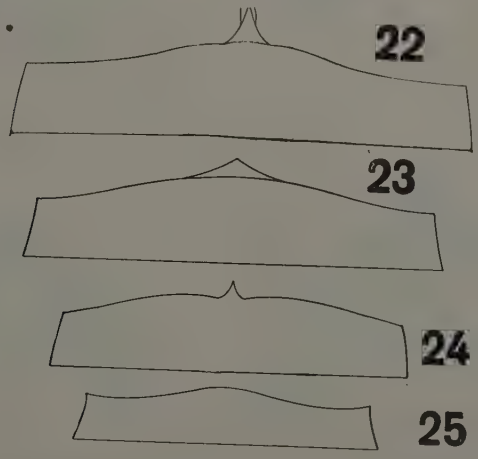
The maxillary brush of the first instar (Fig. 21, MxB) is small and consists of 11 to 15 simple hairs and a very few, short pectinate hairs. The maxillary brush of the second instar (Fig. 20, MxB) is a little longer and consists of 14 to 19 simple hairs, plus a few short pectinate hairs. The brush of the third instar (Fig. 21, MxB) is larger and consists of 19 to 23 simple hairs, in addition to the pectinate hairs which are more numerous than those of the earlier instars. The maxillary brush of the fourth instar (Fig. 18, MxB) is composed of 23 to 28 long simple hairs, plus a great number of pectinate hairs. The number of sensoria which are attached to the distal end of the maxillary palpus vary in number during the course of development. There are four sensoria in the first and second instars (Figs. 20 and 21, S). In the third instar (Fig. 19, S) there are five sensoria, while in the fourth instar there are six sensoria (Fig. 18, S). The mesal margin of the maxilla of the first instar is provided with numerous spines and setae, which increase in number and length in the second instar. After the second moult, in the third instar, a number of pectinate spines (Fig. 19, PcSp) are developed at the caudal region of the mesal margin. In the fourth instar, these pectinate spines (Fig. 18, PcSp) are longer and more pigmented.

The mentum of the first instar (Fig. 25) is a narrow plate, with a simple convex cephalic margin. The mentum of the second instar (Fig. 24) is a little larger, with its cephalic margin produced mesad into a short triangular shaped projection. In the third instar, this projection (Fig. 23) has a wider base, and in the fourth instar, it is longer, more pigmented and possesses two slender spine-like setae which arise from its lateral margin (Fig. 22).

The glossa of the first instar (Fig. 29) consists of 22 to 26 bipectinate hairs; each of these bipectinate hairs bears at least two or three branches. The glossa of the second instar (Fig. 28) consists of 34 to 44 bipectinate hairs, which also include one

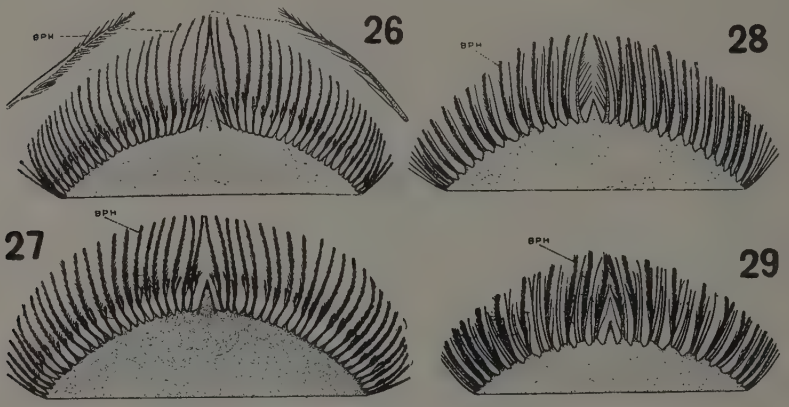


FIGS. 18-21 : Ventral aspect of the left maxilla of the fourth, third, second, and first instar larva, respectively.

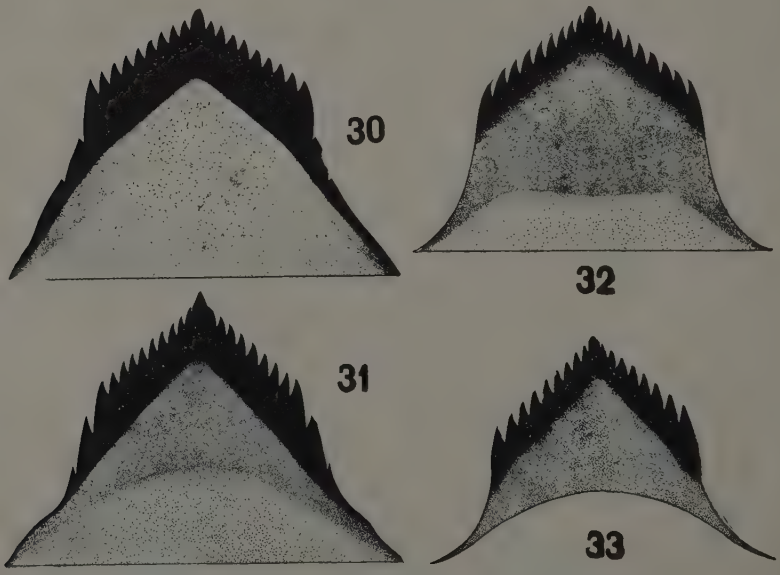


FIGS. 22-25 : Ventral aspect of the mentum of the fourth, third, second, and first instar larva, respectively.

or two branches each. The fringes of the glossae of the third and fourth instars (Figs. 27 and 26) range from 48 to 52 unbranched bipectinate hairs.

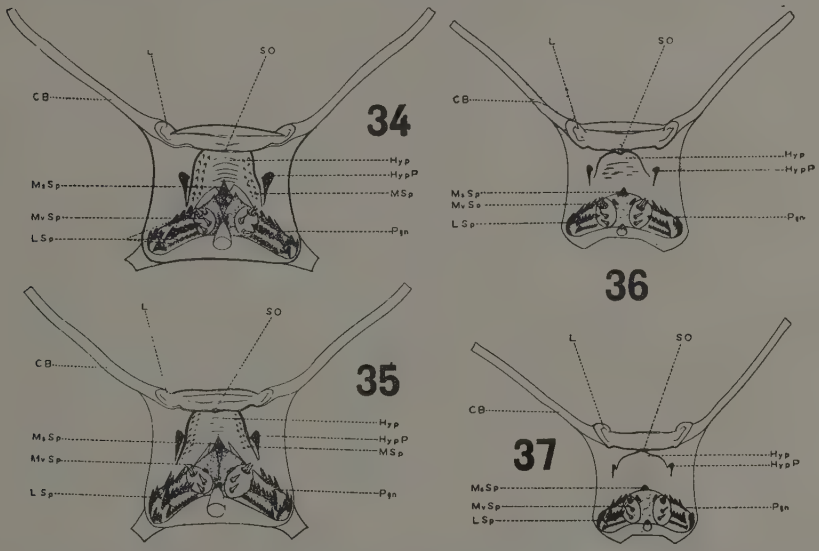


FIGS. 26-29 : Ventral aspect of the glossa of the fourth, third, second, and first instar larva respectively.



FIGS. 30-33 : Ventral aspect of the paraglossa of the fourth, third, second, and first instar larva, respectively.

The paraglossa of the first instar (Fig. 33) is asymmetrical and consists of 18 teeth, eight teeth on the left side, nine teeth on the right side and a disto-central tooth. The paraglossa of the second instar (Fig. 32) consists of 19 teeth, with nine teeth on each side of the disto-central tooth. The paraglossa of the third instar (Fig. 31) is composed of 24 teeth, 11 teeth on the left side, 12 teeth on the right side, and a disto-central tooth. The paraglossa of the fourth instar (Fig. 30) is composed of 23 large teeth, with 11 teeth on each side of the disto-central tooth.



FIGS. 34-37 : Ventral aspect of the hypopharynx of the fourth, third, second, and first instar larva, respectively.

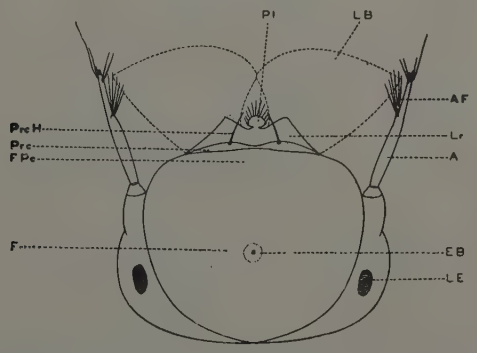


FIG. 38 : Dorsal aspect of the head of the first instar larva showing the presence of the egg burster (EB) in the middle of the frons.

The hypopharynx of the first instar larva (Fig. 37) is small. Its median region (Hyp) contains no transverse ridges or microspines. The median region of the hypopharynx of the second instar (Fig. 36, Hyp) contains very few ridges but does not contain microspines, while that of the third and fourth instars (Figs. 35 and 34, Hyp) contain both the ridges and the microspines. There are no significant differences between the paragnatha of the four instars except in the degree of sclerotization and pigmentation, and a slight irregular increase in the number of spines after each moult.

IX. KEY TO THE LARVAL INSTARS

1. Egg burster on the dorsal side of the frons absent 2

1 a. Egg burster on the dorsal side of the frons present (Fig. 38, EB). Head about 0.468 mm. in width. Fronto-clypeal suture absent. Postclypeus fused with frons forming fronto-postclypeus (Fig. 5, FPc). Ventral dentes of mandible five and serrated dentes one (Figs. 13 and 17, VDt and SrDt). Serrated processes of mandible five to nine (SrP). Pectinate spines at the caudo-mesal margin of maxilla absent. Sensoria of maxillary palpus four (Fig. 21, S). Mentum without meso-cephalic projection (Fig. 25). Glossa with 22 to 26 branched bipectinate hairs (Fig. 29). Bipectinate hairs with at least two branches. Paraglossa asymmetrical, slightly sclerotized and with 18 teeth (Fig. 33).. ..... **First instar**

2. Fronto-clypeal suture and pectinate spines at the caudo-mesal margin of maxilla, present..... 3

2 a. Fronto-clypeal suture and the pectinate spines at the caudo-mesal margin of maxilla, absent. Postclypeus fused with the frons forming fronto-postclypeus (Fig. 4, FPc). Head about 0.536 mm. in width. Ventral dentes of mandible five and serrared dentes two (Figs. 12 and 16, VDt and SrDt). Serrated processes of mandible, from 9 to 12 (SrP). Simple hairs of maxilary brush from 14 to 19 (Fig. 20, MxB). Sensoria of maxillary palpus, four (S). Mentum with a small meso-cephalic projection (Fig. 24). Glossa with 34 to 44 branched bipectinate hairs (Fig. 28). Bipectinate hair with not more than two branches. Paraglossa symmetrical, sclerotized, and with 19 teeth .....**Second instar**

3. Head about 1.071 mm. in width. Postclypeus not fused with frons. Ventral dentes of mandible six (Figs. 11 and 15, VDt). Plumose hairs of mandible eight (Fig. 11, PH). Mandible with 13 to 17 serrated processes (Figs. 11 and 15, SrP). Simple hairs of maxillary brush from 19 to 23 (Fig. 19, MxB). Sensoria of maxillary palpus five (S). Mentum with a wide-based meso-cephalic projection (Fig. 23). Glossa with 48 to 52 unbranched bipectinate hairs (Fig. 27). Paraglossa sclerotized, pigmented and with 24 teeth (Fig. 31) ..... **Third instar**

3 a. Head about 1.105 mm. in width. Mandible with nine plumose hairs (Fig. 10 PH). Mandible with more than 17 serrated processes (Figs. 10 and 14, SrP). Maxillary brush with 23 to 28 simple hairs (Fig. 18, MxB). Sensoria of maxillary palpus six (S). Meso-cephalic projection of mentum, with two lateral spine-like setae (Fig. 22). Paraglossa quadrangular in shape, heavily sclerotized, heavily pigmented with 23 large teeth ..... **Fourth instar**

X. ACKNOWLEDGMENTS

Indebtedness and gratitude are due to Professor WILLIAM P. HAYES, the Head of the Department of Entomology at the University of Illinois.

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THE DEVELOPMENT OF EGGS OF SOME EGYPTIAN SPECIES OF GRASSHOPPERS, WITH A SPECIAL REFERENCE TO THE INCIDENCE OF DIAPAUSE IN THE EGGS OF *EUPREPOCNEMIS PLORANS* CHARP.

[*Orthoptera* : *Acridiidae*]

(with 7 Text-Figures and 8 Tables)

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CONTENTS

I. Introduction. — II. Material and method. — III. The embryonic development in *Euprepocnemis plorans*. — IV. Influence of water on the development of eggs : 1, *Euprepocnemis plorans*; 2, *Aiolopus thalassinus*; 3, *Aiolopus savignyi*. — V. Water absorption. — VI. Diapause in the eggs of *Euprepocnemis plorans* : 1, Development at 28°C.; 2, Development at 38°C.; 3, Development at room conditions; 4, Influence of low temperature on the elimination of diapause. — VII. The permeability of the hydropyle : 1, *Euprepocnemis plorans*; 2, *Aiolopus thalassinus*; 3, *Aiolopus savignyi*; 4, *Thisoicetrus littoralis*. — VIII. Discussion. — IX. Summary. — X. References.

I. INTRODUCTION

All species of Acridiidae occurring in Shebin El-Kom, south of the Nile Delta, deposit their egg-pods in the soil. Most of the species are sexually mature and females are ready to oviposit when favourable temperature and soil moisture are provided. But in winter adults and hoppers of *Aiolopus savignyi* and *Euprepocnemis plorans* undergo heavy mortality and the winter is passed in the egg-stage. It is known

that water is absorbed by developing eggs and in *Schistocerca gregaria* it has been shown by SHULOV (1952) that eggs normally absorb about their own initial weight of water. SALT (1949) found that the total amount of water absorbed by the eggs of *Melanoplus bivittatus* was about 60% of the original weight of the egg and that about 88% of the total absorption occurred during the early period of development.

Grasshopper eggs differ in their ability to secure their water requirement from the environment; in some species eggs can absorb water vapour from the atmosphere but in others contact water is essential. The present investigation is a comparative study between some Egyptian species of grasshoppers and it aims at an understanding of the conditions necessary for their successful embryonic development. The present author (1956b) found that grasshoppers differ in their choice of soil moisture. *Aiolopus savignyi* and *A. thalassinus* prefer moist soil, while *Euprepocnemis plorans* prefers a drier type of soil. But *Acrotylus insubricus* and *Chrotogonus lugubris* do not seem to have any definite preference for any degree of soil moisture. Egg-pods are indiscriminately deposited in soils of different moisture contents. This indifference to soil moisture indicates that such eggs may have a great power to secure water from dry soil as well as a great ability to resist desiccation. These points need further study.

In locuts and grasshoppers the egg is an oval structure, slightly flattened on the dorsal side and is covered by a tough chorion. The posterior end is characterized by the micropylar cone over which the chorion is more permeable to water than elsewhere. A special structure for the absorption of water is developed from the serosal cells at the micropylar end. The whole structure is known as the hydropyle and it is responsible for the uptake of water which begins some time after the egg has been laid. The mechanism of water absorption has been described by SLIFER (1938b, 1949a and b) in the eggs of *Melanoplus differentialis* and by MATTHÊE (1948, 1951) in the eggs of *Locustana pardalina*.

The role of water in the embryonic development of *Aiolopus thalassinus*, *A. savignyi* and *E. plorans* has been studied in detail. It has been found that if eggs of *E. plorans* are deprived of contact water embryonic development stops at an early stage of development, when water is added development is resumed and hatching occurs. But the problem is made difficult by the interference of a diapause stage which lasts for several months.

It has long been known that the embryo in Orthoptera and many other orders undergoes when it is partially developed a turning process. This and other movements of the embryo have been known as blastokinesis. This process has been described under two headings; anatrepsis and katatrepsis (JOHANSEN and BUTT, 1941). During anatrepsis the embryo grows and its abdomen extends towards the anterior pole of the egg; during katatrepsis it moves head first around the posterior pole and then proceeds towards the anterior pole. When development has been completed the head of the embryo is close to the anterior pole of the egg.

II. MATERIAL AND METHODS

Grasshoppers are easy to keep and rear in the laboratory. Adult grasshoppers were collected in the field between June and September and kept in cages 40 — 50 cm. at the base and 40 cm. high. The sides and top were of wire-netting and there was a front door which was 40 × 40 cm. The wooden floor could be separated from the body of the cage and it had 20 holes in which 20 egg-tins (each 8 cm. deep by 5 cm. diameter) were placed. The tins were filled with soils of different moisture content and offered to the grasshoppers for deposition of eggs (KHALIFA, 1956b). When the egg-pod was newly laid the spongy pad was white and very soft, the egg-chorion was also white and smeared with a viscous fluid. A few hours later the coarsely-meshed spongy pad got dark in colour and hardened. In some experiments the egg-pods were left in the soil and the egg-tins were placed in small muslin sacks tied at their open ends with pieces of string in order to keep nymphs that would hatch. Egg-tins were divided into 4 groups : the first was placed in an incubator running at 28°C., the second was placed at 38°C., the third was placed under room conditions; and the fourth was put out-of-doors. In another experiment egg-pods were taken out of the soil and placed on wet plaster of Paris either at 28, or 38°C., or at room conditions. The containers were also covered with muslin in order to keep hoppers that would hatch.

Eggs were separated from their pods and used for different purposes. A batch of eggs was used to study the development of embryos in relation to water. Test tubes 17 cm. long and 3 cm. diameter were used to hold amounts of sulphuric acid solution of known specific gravity. In another glass tube (about 13 cm. long and 2 cm. diameter and open at both ends) a piece of cotton-wool was inserted and placed at about 1 cm. from one end of the tube. Several eggs were placed on the cotton-wool and the tube was placed in the test tube holding the sulphuric acid; a cork was tightly fixed. A gradient of relative humidity was prepared following the procedures of BUXTON and MELLANBY (1934) and SOLOMON (1951). A few number of eggs were taken at intervals in order to study the blastokinetic movement. Katatrepsis could be detected by following the position of the eyespots. These could be seen through the chorion when eggs were smeared with water using reflected light. When the embryo was at earlier stages of development blastokinesis was studied by removing the chorion using SLIFER's method (1945). An approximately 3% solution of sodium hypochlorite dissolved the brown, nonchitinous chorion and the yellow cuticle in less than 10 minutes. The embryo was then left with the serosal chitinous white cuticle which was thicker than the chorion but clear and transparent. The eggs were then transferred to water, mounted on a slide and examined under a binocular microscope.

The permeability of the hydropyle in eggs of different species of grasshoppers in diapause or at known embryological stages was examined using SLIFER's method (1949b). Eggs of known age or history were washed repeatedly in distilled water

and transferred to a 50 cc. flask which contained just enough stain to cover the eggs about half way. The stain used was a 1 % solution of iodine in 10 % potassium iodide. The flasks were then corked and placed in the incubator. Each day the flasks were filled with distilled water, and this when poured off insured a complete change of the CO_2 accumulating within the flasks. A similar quantity of fresh dye solution was then added. Eggs were taken out at intervals, air dried and examined in xylol under a binocular microscope. The extent to which the iodine had affected the eggs was determined.

III. THE EMBRYONIC DEVELOPMENT IN *EUPREPOCNEMIS PLORANS*

The embryology of Acridiidae has been studied by several authors : SLIFER (1931, 1932a, b and 1934) in *Melanoplus differentialis*; ROONWALL (1937 and 1938) in *Locusta migratoria*; STEELE (1941) in *Austroicetes cruciata*, and MATTHÈE (1951) in *Locustana pardalina*. In its course of development the embryo in *E. plorans*, *A. thalassinus*, *A. savignyi* and *Thisoicetrus littoralis* follows generally the different stages described by the above mentioned authors. But the object of this account is to describe six stages of embryonic development in order to study, firstly the rate of growth under different ecological conditions, and secondly to show at what stage the embryo enters into diapause in *E. plorans*. The stages described in this account refer mainly to the embryo of *E. plorans*, but they give also the main stages of development which are found in all other species of locusts and grasshoppers. The stages described here are for embryos obtained from eggs kept at 28°C. from the time of laying. Embryos when examined were fixed in Bouin's fluid or in 50 % alcohol. A few drops were placed on a slide, an egg was placed in the fluid and its posterior tip was cut off. The embryo was gently squeezed out into the fixative and about ten minutes were allowed for fixation. Embryos so treated can be easily moved about in the fixative without being injured, they were then examined and measured. In a few cases embryos were stained in Delafield's haematoxylin, dehydrated, cleared in zylol and mounted in Canada Balsam.

The youngest embryo examined was from eggs 6 days old (Fig. 1,A). The embryo is divisible into the two main parts; the protocormic region which grows long and ribbon-like and the protocephalic lobes (cranial region) which expand laterally. Embryo is about 0.7 mm. long and the egg had not yet attained its full extended size. Eggs 9-11 days old contain fully formed serosal cuticle and have increased considerably in size. The embryo (stage B) continues to move tail first towards the anterior pole of the egg, and its posterior end approximates the middle of the egg. The anterior end of the embryo is a little distance from the micropyle cap, and the clear amniotic fluid accumulates at the micropyle end between the posterior boundary of the yolk and the hydropyle. At this point the strand of the serosal cells is slightly

stretched. The protocormic region is differentiated into a thoracic and abdominal regions. Eggs 16-18 days old contain embryos at full anatrepsis (stage C). The embryo is considerably broad and comparatively flat but the lateral walls have

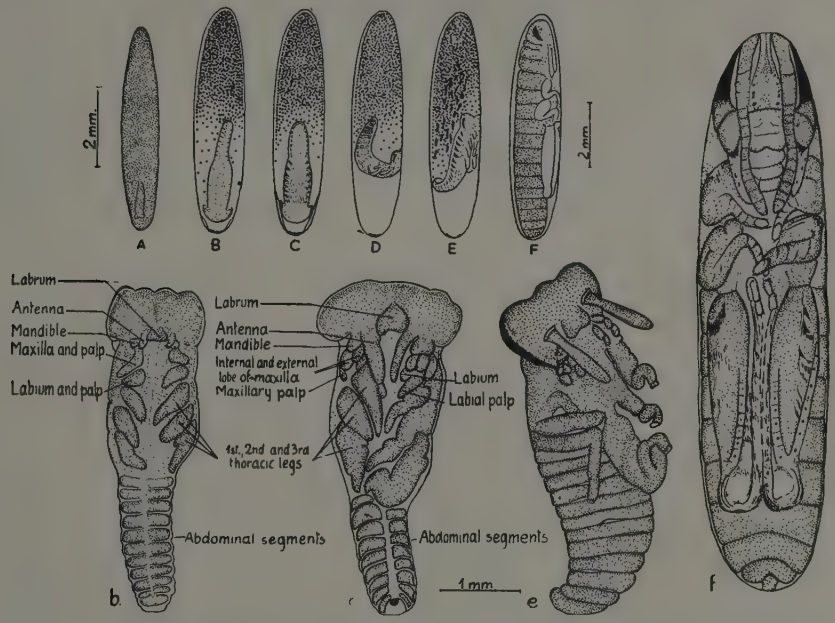

FIG. 1: Six stages in the development of the embryo in *Euprocnemis plorans* : A, the differentiation of the protocephalic and the protocormic regions; B, the embryo approaching anatrepsis, the amniotic fluid appearing at the posterior end of the egg and the body of the embryo undergoing segmentation; C, anatrepsis stage; D, the revolving process; E, mid-katatrepsis; F, full katatrepsis.— In b, c, e, and f, embryo enlarged.

begun to encircle the yolk. Segmentation is conspicuous, it commences at the anterior end and gradually extends to the posterior end. The embryo occupies nearly one third of the size of the egg and its middle lies just posterior to the middle of the egg. The amniotic fluid is increasing in quantity and the strand of the serosal cells is greatly stretched. A specialised ocular region in the protocephalic lobes becomes well marked and eye pigment is very conspicuous. This stage marks the end of anatrepsis.

In non-diapause eggs the embryo after about 19-22 days from laying undergoes the revolving process (stage D), this is the beginning of katatrepsis. The anterior region is strongly flexed backward, and the embryo starts to move in the opposite direction. The embryo turns head first around the posterior boundary of the yolk

and moves towards the anterior pole of the egg. When this movement begins the head of the embryo breaks through the serosa, and eventually the strand of the serosal cells breaks off but remains attached to the hydropyle. Three days later, 22-25 days from laying, the head reaches nearly the middle of the egg and the abdomen straightens out (stage E). The body walls of the embryo meet in the mid-dorsal line starting at the posterior end of the abdomen and proceeding towards the anterior end. The embryo continues to move forward and increases in length until the head reaches the anterior pole of the egg (stage F). The lateral body walls have grown up, completely engulfed the yolk and have met and fused along the mid-dorsal line. This is the end of katatrepsis which is reached after about 26-30 days from laying. Subsequent development consists largely of an increase in the differentiation and growth of the body parts.

IV. INFLUENCE OF WATER ON THE DEVELOPMENT OF EGGS

1. Euprepocnemis plorans

In locusts and grasshoppers the development of eggs is closely dependent on soil moisture and on the relative humidity of the air in the soil spaces. The soil spaces and the minute cavities between the eggs in the egg-pods are always filled with either free water or with air of different relative humidities. When soil gets dry it contains no available water and its moisture content comes down to 5.7%, the relative humidity of the air in the soil spaces must be below the saturated condition.

It is clear, therefore, that eggs of *E. plorans* which have such a long incubation period, nearly eight months, would be subject to alternating periods of soil having available water, and to air of different relative humidities. Two series of experiments were undertaken. The first was to determine the fate of eggs at various air humidities when not in contact with water. In the second experiment egg-pods were laid in soils of different moisture contents ranging between 43.5 and 17.1%; this is the maximum and minimum limits of soil moisture acceptable for the deposition of egg-pods (KHALIFA, 1956b). Soils were no longer watered and when hoppers hatched or eggs examined moisture content of the soil was determined.

In the first experiment 60 eggs were placed on a plug of cotton wool in each of the tubes referred to above. Eggs were exposed to seven degrees of relative humidities ranging from 10 to 100% and the experiment was carried out at 28°C. None of these eggs hatched and in a month's time those which were at 10, 20, 30 and 60% R.H. shrivelled up and dried. A very few number, about 10%, of those kept at 80 and 95% R.H. were soft, shrunken but alive and when examined they were found to contain small embryos near stage B, others were dry and dead. But all eggs kept at 100% R.H. were still alive when examined after a month from the beginning of the experiment, and embryo was at a similar stage of development as those kept at 80 and 95% R.H. Those when transferred to wet plaster of Paris started to absorb

water and when examined a month later 34 eggs were found to contain embryos at katatrepsis, 20 at anatrepsis and 6 were dead. It can be concluded that *E. plorans* eggs cannot develop beyond a certain stage, prior to anatrepsis, when kept at 100% R.H. and that contact with water is essential for further development. SHULOV (1952) found that all eggs of *Schistocerca gregaria* died within 6 days after oviposition when kept at 80% R.H., and at temperatures ranging from 20 to 30°C. A few number of the eggs kept at 90% R.H. and nearly all those kept at 100% R.H. and 27°C. where still alive after 95 days from the beginning of the experiment. Those when examined were found in various stages of anatrepsis, and they failed to hatch when wetted. But embryos in eggs kept at the same temperature but in contact with water were in the stage of late anatrepsis and ready to revolve in five days, hatching begins after 14 days.

E. plorans can lay its eggs in soils containing different amounts of moisture. But it has been shown (KHALIFA, 1956b) that it prefers for egg-laying soils which contain a moderate amount of moisture, 24.2% (water present to dry weight of soil x 100). The second experiment was undertaken in order to find out the effect of soil moisture on the viability and hatching of eggs. The experiment was carried out under room conditions; several hundreds of eggs were laid in soils of different moisture contents on 4th and 14th October 1953 and soils were not wetted afterwards except when stated. There were five treatments of soil moisture : 43.5, 34.5, 25.5, 21.1 and 17.1%. In the first two treatments eggs hatched at the same time as those which were deposited in soil kept continuously wet; of 291 eggs 176 hatched on 22nd, 112 on 24th and 3 on 28th April 1954. After 1st May 1954, when hoppers ceased to emerge some pods were taken out of their tins and eggs examined; others were left under these conditions for periods ranging from 198 to 359 days. Soil moisture was determined at the end of the experiment. The number of hoppers which hatched and number of embryos at katatrepsis, anatrepsis and those which were found dead are recorded in Table. I, the percentages are represented in Figure 2.

TABLE I

Egg-pods deposited in soils of different moisture contents

Reference	Moisture percentage		Number of hoppers hatched	Number of embryos			Remarks
	at beginning of experiment	at end of experiment		Katatrepsis	Anatrepsis	Dead	
A	43.5	6.7	267	0	7	277	Dead mature embryos
B	34.5	6.7	399	1	0	380	
C	25.5	7.4	0	0	176	0	Early stage of anatrepsis
D	21.1	5.3	0	1	291	187	— do —
E	17.1	6.7	0	0	95	201	— do —

It can be observed that hoppers hatched only in soils which contained 43.5 and 34.5% moisture. In the first treatment there were a very few number of eggs at anatrepsis, none at katatrepsis and all dead embryos were fully mature ones. In the second treatment there was no much difference save that the embryo in the dead eggs was at an earlier stage of development and fully mature ones were not encountered. In the third treatment all eggs were found to contain embryos very near to stage B (Fig.1), but they were smaller in size and the yolk was in the form of a clear yellow thick fluid. Another egg-tin containing five egg-pods and soil of the same near treatment was exposed for 166 days to 100% R. H. in a desiccator. At the end of this period soil moisture rised to 14.0% and when eggs were examined they were

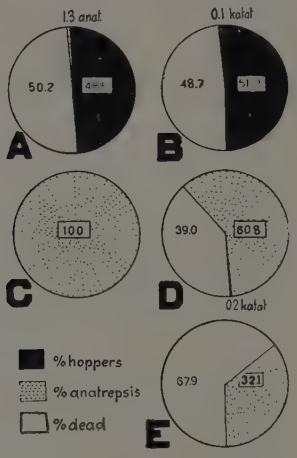

FIG. 2 : The percentage of different stages of embryonic development in eggs deposited by *Euprepocnemis plorans* in soils of different moisture contents (A, B, C, D and E, see Table I).

all found alive and contained embryos at the same stage of development. The increase of soil moisture from 7.4 to 14.0% had no further effect on the development of embryos. One more egg-tin containing five egg-pods and soil of the same treatment was exposed for 140 days to 100% R. H. in a desiccator and then watered. Twenty three days later when 17 hoppers emerged all other eggs (158) were taken out of the soil and examined. 74 contained embryos at stage F, 15 at E, 2 at D, 13 at C, 46 at B and 8 were found dead. A third egg-tin containing four pods and soil of the same treatment was watered 308 days from oviposition. After 23 days 22 nymphs hatched and when other eggs (180) were examined 47 days later 22 were found to contain embryos at stage C, 53 at B and 105 were found dead and moulded. It is clear, therefore, that in this treatment where females oviposited in soil containing 25.5% moisture, which appeared to be most favourable for egg-laying, embryos

were not capable of attaining katatrepsis or even complete anatrepsis because of lack of water. When this was added embryos resumed development and hatched.

It the fourth treatment live eggs were found to contain embryos at early anatrepsis, stage B, and there was a great number (39%) which was found dead. There was only one egg (0.2%) which was found to contain an embryo at full katatrepsis. Another egg-tin containing one pod and soil of the same treatment was watered 267 days from oviposition and eggs were examined 20 days later. 6 were found to contain embryos at full anatrepsis and 29 eggs were dead. They most probably had died before soil was watered. In the fifth treatment there was no much difference save that there were more dead eggs than live ones. One egg-tin containing two pods was exposed for 140 days to 100% R.H. and at the end of this period soil moisture was found to be 13.2% and all eggs contained embryos very near to stage B.

From these observations it can be concluded that in the absence of contact water the embryo of *E. plorans* develops until an early stage of anatrepsis is reached, provided that eggs are exposed to a high degree of relative humidity, 80-100%. From the second experiment it was deduced that soil spaces would contain air of 100% R.H. when soil moisture was above 13.2 or 14.0%. If soil moisture was less than that the air between soil particles was apt to contain dry air and therefore a great number of eggs was found dead. The highest percentage of dead eggs occurred when females oviposited in soil containing very little amount of available water, 3% (17.1-14.0 = 3.1%). Some of this water was lost by evaporation and the remaining part was absorbed and initiated development in 32.1% of the eggs. Under such dry soil conditions eggs, containing embryos at early anatrepsis, remain alive for nearly a year and most likely can live longer and resume development when water is available.

2. Aiolopus thalassinus

This grasshopper is abundant and its stages occur at all times of the year. The eggs deposited in wet soil hatched in 18-22 days at 28°C. without further addition of water. When eggs were placed at a gradient of relative humidity at 28°C. it was found that all eggs exposed to 10, 20, 60, 80 and 95% R.H. shrivelled up and died when they were examined a month later. At 100% R.H. eggs developed at a slower rate and hoppers hatched in 33-46 days; but there was a high percentage of mortality due to the growth of mould. Some of the dead eggs were examined and they were found to contain embryos at full katatrepsis.

There was no great difference in the rate of development of eggs when kept at 28°C. in wet soil or on wet plaster of Paris. In most eggs anatrepsis was reached in 9 days from laying, mid-katatrepsis (stage E) in 10 days, full katatrepsis in 12-14 days and the remaining period, almost a week, was spent in growth of the different body parts. The following experiments were carried out with eggs kept in contact with water for different periods and their embryological stages were known. From 40-50 eggs were exposed to different degrees of relative humidity. This was to ascer-

tain whether the amount of water already taken in would enable them to develop not only under conditions of water equilibrium, but also when they were liable to lose water as a result of exposure to reduced humidities. Results are shown in Table IIA.

TABLE II

Effect of air humidities on eggs kept in contact with water for different periods : +, eggs hatched; — eggs failed to hatch (Experiment at 28°C.)

Days in contact with water	Stage	Percentage Relative Humidity								On wet cotton wool
		0	30	45	60	70	80	95	100	
	A. Aiolopus thalassinus									
5	Early develop. Stage A.	—	—	—	—	—	—	—	+	+
9	Anatrepsis. Stage C.	—	—	+	+	+	+	+	+	+
10	Mid-katatrepsis Stage E.	—	—	+	+	+	+	+	+	+
12	Full katatrepsis Stage F.	—	—	+	+	+	+	+	+	+
	B. Aiolopus savignyi									
8	Anatrepsis, eye not coloured.	—	—	—	—	+	+	+	+	+
12-13	Full katatrepsis. Stage F.	—	—	+	+	+	+	+	+	+

In the first experiment eggs were kept in contact with water for 5 days, and embryo was at an early stage of development (stage A). Hoppers began to emerge in the tube containing 100% R.H. 22 days later, whereas the incubation period was 21 days in eggs kept on wet cotton-wool from the time of laying. 7 out of 40 eggs hatched, others were destroyed by mould. Of the 40 eggs kept at 95% R. H. only 10 were found alive and contained embryos at an early stage of anatrepsis, others were dead and slightly moulded. At this degree of relative humidity eggs were able to absorb little amounts of moisture only sufficient to stimulate development. The eggs which were exposed to other relative humidities were all found shrivelled up and dead.

In the second experiment eggs were kept in contact with water for 9 days, and embryo was at anatrepsis. Eggs began to hatch in most of the tubes after 13-14 days from their exposure to air of 45-100% R.H. The incubation period of such eggs, 22-23 days, approximated that of eggs kept continuously on wet-cotton wool, 20-22 days. Eggs exposed to 0 and 30% R.H. did not hatch, they all dried up and collapsed. There was an increase in the percentage of hatching as the relative humidity increased

(Fig. 3). At 45 and 60% R.H. though the percentages of hatching were low, 16.0 and 34.0% respectively, yet this showed that eggs absorbed, when kept in contact

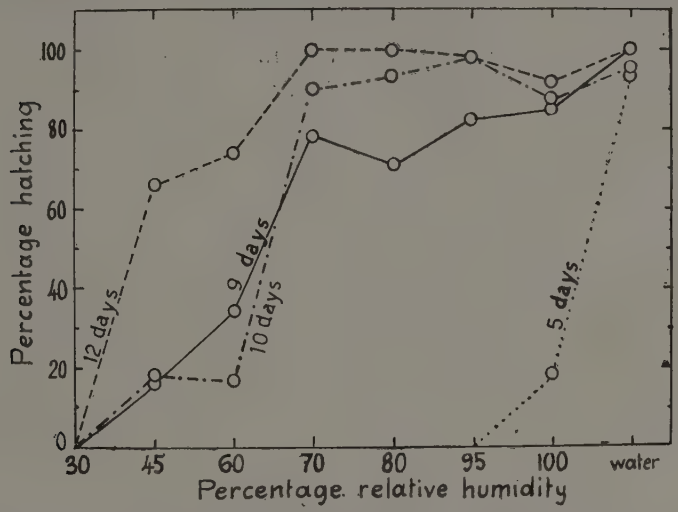

FIG 3 : Percentage of eggs of *Aiolopus thalassinus* which hatched when kept in contact with water for 5, 9, 10 and 12 days and then transferred to a gradient of relative humidity

with water for 9 days, an ample amount of water sufficient to accomplish complete development. When eggs were exposed to such humidities from the time they were laid it was found that they all lost their moisture, collapsed and died.

In the third experiment eggs were kept in contact with water for 10 days and embryo was at mid-katatrepsis (stage E). Eggs started to hatch in most of the tubes after 11-13 days from their exposure to air of 45-100% R.H. The total incubation period of these eggs, 21-23 days, approximated that of eggs kept from the time they were laid on wet cotton-wool, 20-22 days. Eggs exposed to lower relative humidities did not hatch, they all lost their water and died. There was no difference between the percentage of eggs hatched at 45 and 60% R.H. (Fig. 3); but at 70, 80 and 95% R.H. the percentage of hatching was generally higher than that of the previous experiment.

The fourth experiment was carried out on eggs kept in contact with water for 12 days, and embryo was at full katatrepsis. Eggs commenced to hatch after 8-11 days from their exposure to 45-100 R.H., and also in eggs kept continuously in contact with water. The incubation period in all cases was 18-21 days. Eggs exposed to 0 and 30% R.H. shrivelled up and died. The percentage of hatching was generally higher than in other treatments as shown in Figure 3. The slight drop in the percentage of hatching in eggs exposed to 100% R.H. was due to the effect of mould.

3. Aiolopus savignyi

The eggs of this species do not hatch during winter because the temperature needed for development is higher than what is prevailing in the field. In autumn and winter embryos devolp till anatrepsis is reached, then development is interrupted until the beginning of spring. Under laboratory conditions when eggs were subjected to a higher temperature (i.e. 25°C.) than that prevailing in the field during winter, nymphs emerged and normal development took place.

The effect of air humidities on eggs of *A. savignyi* kept in contact with water for different periods is shown in Table IIB. When eggs were kept in contact with water for 8 days and embryos were at early anatrepsis (eye-spots were not coloured) hatching occurred in those kept at 70% and higher degrees of relative humidities 13-15 days later. The percentage of hatching increased from 24.4 to 90% at 70 and 100% R.H. respectively. In eggs exposed to the gradient of relative humidity when embryos attained full katatrepsis hatching occurred in those kept at 45% and higher degrees of relative humidity 10-11 days later. The percentage of hatching was 47.5 at 45% R.H. and increased to 95% at 100% R.H. In this experiment the percentage of hatching at any particular humidity was higher than that in the preceding one.

V. WATER ABSORPTION

The moisture content of developing eggs of *E. plorans* was taken as a means of assessing the rate of water absorption during the incubation period. Egg-pods deposited in wet sand and kept from the time of laying at 38°C. were taken out at varying intervals. Every day, during the developmental period, random samples of eggs were dissected out of the pods, immersed in distilled water to wash off all sand, dried on filter paper for 10 minutes and then in a desiccator for 20 minutes to secure complete evaporation of water from the surface of the eggs. In every case three groups consisting of ten eggs each were selected each day, weighed and dried in an electrically heated oven at 110°C. for 2 1/2 hours. The results of these moisture determination are presented graphically in Figure 4.

It will be noted that water content remained nearly constant during the first two days of incubation. This was followed by a rapid increase in the rate of water uptake till the 6th or 7th. day when most embryos reached anatrepsis. There was an almost complete cessation of water absorption in the following period irrespective of whether the embryos entered the stage of diapause or underwent further development. On the 11th day the water content of a group of eggs in which the embryo was at anatrepsis was 76.32% while in another batch were the embryo was at katatrepsis was 75.88%. On the 17th. day when non-diapause eggs were about to hatch the water content of the egg was 78.76%, while in those where the embryo remained at anatrepsis was 78.01%. An inspection of the eggs showed that katatrepsis, which started in some eggs on the seventh day of incubation, was completed

in non-diapause eggs on the 10th or 12th. day. The point at which anatrepsis was completed, indicated with an arrow in Figure 4, marks the turning point of the curve. It appears, therefore, that most of the water is absorbed during anatrepsis.

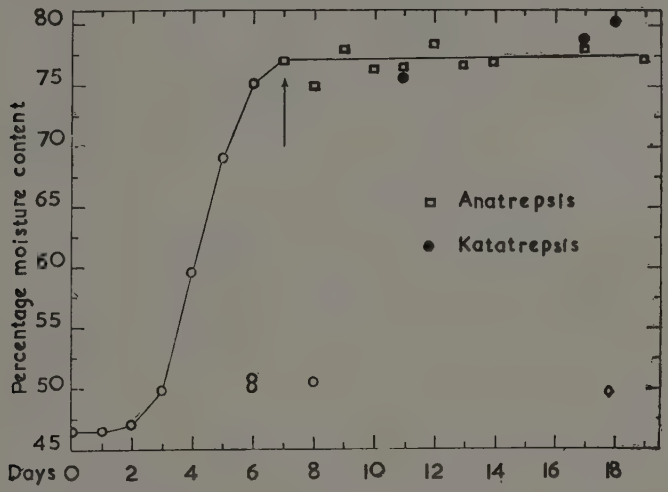

FIG. 4 : The moisture content of developing eggs of *Euprepocnemis plorans* at 38° C.

In the course of this study an aberrant type of eggs was encountered. In some egg-pods there was a number of eggs which did not absorb an appreciable amount of water. On the 6th. and 8th. day of incubation a great number of them were found among others which developed normally in the same pod. They were smaller in size, their water content ranged between 49.89 and 50.81 %, and there was no appreciable development in the embryo. These might be unfertilized eggs.

VI. DIAPAUSE IN THE EGGS OF *E. PLORANS*

Diapause has been considered by ANDREWARTHA (1952) as a stage of physiological development which must be completed as a prerequisite for the resumption of morphogenesis. Diapause may occur in any stage of the life cycle, and in certain species of locusts and grasshoppers it occurs in the egg-stage. Diapause sets in when the embryo reaches a certain stage of development. It has been shown by SLIFER (1932 b) and BURDICK (1937) that the grasshopper *Melanoplus differentialis* lays two types of eggs. With the majority of eggs diapause occurs for at least four or five months when the embryo completes anatrepsis; in a small proportion of the eggs diapause does not occur and hatching takes place after 37 days at 25°C. *M.*

bivittatus, *M. femur-rubrum* and *M. mexicanus* undergo diapause while the embryo is at katatrepsis, full grown and nearly ready to hatch (SALT, 1949; PARKER, 1930).

In South Australia the small plague grasshopper *Austroicetes cruciata* lays its eggs in November (summer) and they hatch in the following September (spring). They are characterized by a diapause which inhibits development until they have been exposed to the low temperature of autumn and winter. When eggs, in the early stages of diapause, have been incubated at constant temperature from 25 to 30°C. none has hatched (BIRCH, 1942). It has been stated by ANDREWARTHA (1952) that when the egg of *A. cruciata* is laid it has the capacity to develop to the stage where a blastoderm has been laid down and an early stage embryo "plate like" has been differentiated. At this stage diapause sets in and there will be no further development unless it is exposed (preferably alternately) to low and high temperature.

Conocephalus (*Xiphidium*) *ensiferus* undergoes diapause when the embryo reaches the stage at which it ceased to move tail first over the yolk. It remains stationary for a period before beginning katatrepsis which is the final movement of blastokinesis (WHEELER, 1893). Moreover, it has been shown by MATTHÉE (1951) that the locust *Locustana pardalina* lays two types of eggs; diapause and non-diapause eggs. If the eggs are kept warm from the time that they are laid, they will all develop until the embryo is approaching the completion of anatrepsis. This will occur irrespective of whether the eggs are kept dry or moist. In both types of eggs a period of suspended growth follows even though they are kept warm at 35°C. But the nature of this dormancy differs in the two types of eggs; the diapause eggs enter a state of true diapause and favourable conditions of moisture and temperature will not initiate further growth. They do eventually hatch at irregular intervals after 36 to 95 days or longer, provided they are kept moist and warm. The non-diapause eggs, on the other hand, enter a period of quiesence, and this dormancy persists only as long as the eggs are kept dry. But on moistening at any period development will be resumed and the majority will hatch after 11 days provided they are kept warm and moist from the time they are laid.

Among the different species of grasshoppers found in Shebin El-Kom district *E. plorans* passes through a diapause stage in the egg stage. Egg-pods are generally laid in July and August; some of the eggs hatch and give rise to a second small generation, the others as well as most of the eggs of the second generation go into a state of diapause till next spring when they usually hatch. The experiments recorded in this paper were carried out in order to study the course of development of the embryo of *E. plorans* and to find out the effect of some environmental conditions on the diapause stage.

1. Development at 28° C.

Marked differences have been found in rate of development in eggs from different pods and in eggs of the same pod. Minimum hatching period of eggs kept from the time of laying in wet soil at 28°C. was 40 days. When several eggs were

examined during the incubation period it has become evident that anatrepsis is completed in 16 days, katatrepsis in 26 days and the remaining period (14 days) is spent in differentiation and growth of the different parts of the body. These periods are, by no means, fixed at this particular degree of temperature. One egg-pod containing 50 eggs and kept under the same conditions was examined 35 days from laying. The embryo in 40 eggs was at anatrepsis, in 9 eggs it started revolving and in one egg there was no appreciable development. But it can be deduced from the following observations that non-diapause eggs hatch in 40-60 days at 28°C., while the term "diapause" will be restricted to those eggs that do not hatch within this limit.

A batch of 32 egg-pods containing 701 eggs was laid in 10 egg-tins containing wet soil between 23rd. September and 14th. October 1953. The tins were placed at 28°C. and the soil was kept wet, hoppers that hatched were collected daily and counted. Records for the incubation periods of 543 eggs are shown in Figure 5, other eggs were examined at varying intervals either within the range of the incubation period or after the maximum recorded limit. Some of these eggs would undoubtedly have had a longer incubation period. From Figure 5 it can be observed that

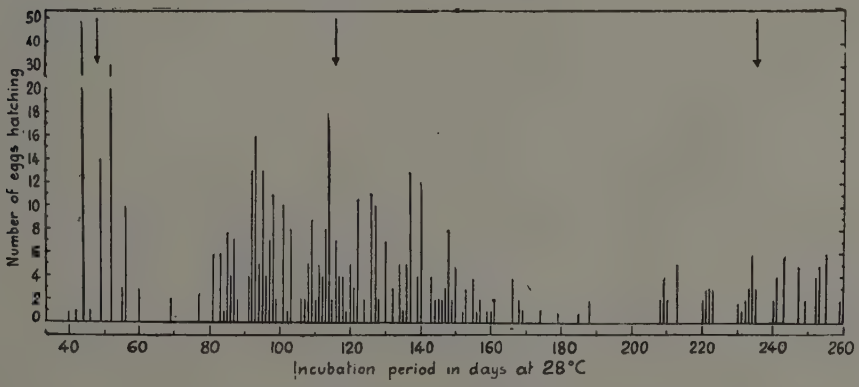

FIG. 5 : The incubation periods of eggs of *Euprepocnemis plorans* kept in wet soil at 28°C. The arrows indicate the means of the three different ranges.

the incubation period varied from 40 to 259 days. But one can distinguish three different ranges; 40-60 days (mean = 48.49 days and standard deviation = 4.801) for 20.44% of the eggs, 69-188 days for 65.38% (mean = 116.48 days and standard deviation = 23.84) and 208-259 days (mean = 234.99 days and standard deviation = 15.26) for 14.18%. The differences between these groups are statistically significant, $P = < 0.001$. This will show that eggs differ greatly in rate of development and that they are undergoing diapause at varying intensities.

The results of examining other eggs are shown in Table III, from which it can be observed that the first two batches (95 eggs) were examined within the range of the incubation period, while the others (63 eggs) were examined after the maximum recorded limit. Two eggs of those undergoing katatrepsis were at stage E, while

TABLE III

Embryonic stages of eggs kept at 28°C. in wet soil

Number of eggs	Number of days	Number of embryos at	
		Anatrepsis	Katatrepsis
35	124	27	8
60	199	60	—
40	280	40	—
14	366	14	—
9	507	9	—
158		150	8

the others were at stage F. The embryo in all the remaining eggs (94.94 %) stopped development when anatrepsis was reached. When diapause ended revolving occurred and development proceeded with no further interruption. Considering the total number of eggs (701) it could be deduced that 84.16 % of the eggs underwent diapause under these conditions.

Several egg-pods were incubated at the same temperature but on moist plaster of Paris. Hoppers that hatched were counted; pods were examined separately in sodium hypochlorite at varying intervals, and their embryonic stages were noted. The result of examining six pods within the incubation period of non-diapause eggs is shown in Table IV. It can be observed that the embryo in 159 eggs was at

TABLE IV

Embryonic stage of eggs kept at 28°C. on wet Paris plaster

Reference number of pod	Number of days	Number of eggs	Number of embryos at	
			Anatrepsis	Katatrepsis
1	58	37	32	5
2	59	23	1	22
3	60	43	35	8
4	60	35	34	1
5	60	31	31	—
6	60	26	26	—
		195	159	36

Number hatched within 60 days = 20
Percentage in diapause = 73.95

anatrepsis, the stage which was generally reached by non-diapause eggs in 16-18 days; 36 eggs had passed this stage and 20 hatched. It can be deduced, therefore, that the embryo in all eggs developed at approximately the same rate till anatrepsis was reached. In non-diapause eggs (26.05%) it continued till hatching occurred, while in 73.95% growth was suspended, and that they were undergoing diapause at varying intensities. It is also clear that individual egg-pods contains the two types of eggs, pods Nos. 5 and 6 contained empty chorions and moulted skins of intermediate instar nymphs.

The result of examining 1006 eggs remained in 30 more egg-pods at varying intervals within the second range of the incubation period, i.e., 69-188 days, showed that the percentage of eggs of suspended growth varied from 86.4 to 100% in individual eggpods, and that they all contained embryos at anatrepsis. Moreover, 375 eggs remained in 11 egg-pods were examined at varying intervals after the maximum recorded limit of the second incubation period and it was found that the percentage of eggs still at anatrepsis, i.e., diapause stage, varied from 25.0 to 100% Some of the embryos were of larger size than what is shown in Figure 1C, having larger and darker eye-spots, white milky in colour instead of the transparent jelly like appearance and having clearer segmentation. Other eggs had similar embryos but shorter and broader. These embryos are encountered 319 days from oviposition, and although they were more advanced yet they were still in diapause, unable to revolve and probably will not hatch if kept continuously under these conditions.

2. Development at 38° C.

Several egg-pods were kept at 38°C. either in wet soil or on moist plaster of Paris. In wet soil the minimum hatching period was 17 days, whereas it was 15 days on moist plaster. 16 egg-pods containing 507 eggs were placed on moist plaster and examined at different intervals in sodium hypochlorite; result is shown in Table V. It can be observed that after 6 days from laying most of the eggs were either at stage A or B, while a few number of them (6.9%) was at an earlier stage of development; embryo was very small and not differentiated. After 10 days all eggs were either at anatrepsis (91.1%) or at more advanced stages of development. After 12 days 66.7% of the embryos stopped development when reached anatrepsis while 33.3% had continued development and 25.6% of them reached full katatrepsis. After 15 days it was found that in 834 eggs 89.4% stopped development when anatrepsis was attained while others had continued development and 0.5% hatched. In another batch of eggs (218) examined after 16 days from laying it was found that 66.5% stopped development when anatrepsis was reached while the others had continued development and 8.7% hatched. It can be noticed, therefore, that all embryos after at least 10 days from laying were either at anatrepsis or at more advanced stages of development. And as 66.7 and 89.4% of the embryos were at anatrepsis when eggs were examined 12 and 15 days from laying respectively, it can be deduced,

TABLE V

Embryonic stages of eggs kept at 28°C. on wet Paris plaster and examined at different intervals.

Number of days from laying	Number of eggs examined	Number and percentage of embryos at stages *							Number of hoppers hatched
		A**	A	B	C	D	E	F	
6	87	6 6.9%	39 44.8%	42 48.3%					
10	124				113 91.1%	2 1.6%	1 0.8%	8 6.5%	
12	78				52 66.7%	2 2.6%	4 5.1%	20 25.6%	
15	834				476 89.4%	0 —	0 —	84 10.1%	20 0.5%
16	218				145 66.5%	1 0.5%	1 0.5%	52 23.9%	19 8.7%

* See Figure 1. — ** An earlier stage of development

therefore, that diapause sets in when anatrepsis is attained in about 78.05% of the eggs when kept at that degree of temperature. In non-diapause eggs there were very few number of embryos at stages D and E, and this was because development proceeded in these eggs at a more or less constant rate and that there was no blockage of development at any stage between anatrepsis and full katatrepsis.

3. Development at room conditions

Conditions in the field are undoubtedly more severe than in rooms and laboratories. In summer the daily air temperature ranges from a maximum of 33-40°C. to a minimum of 18-22°C., the former is generally reached between 2-3 p.m., and the latter between 4-5 a.m. The maximum temperature 3-6 cm. below the surface of the soil reached generally a higher level, the difference may amount to 2-3°C. In the laboratory several egg-pods were kept in moist soil from September 1953, when they were laid, till April 1954 when most hoppers had hatched. The average monthly temperature for this period is shown in Figure 6. But soil temperature in egg-tins kept in the laboratory was always about one degree below that of room temperature. The daily temperature curve shown on a thermograph approximated to a sine curve. In the laboratory the curve was generally flat because the range between the maximum and minimum temperature was not as wide as that in the field. But the variation in seasonal temperature is very great, and it can be observed that while the mean monthly temperature in August was 30.6°C., it was 14.2°C. in January which is generally the coldest month of the year. In July 1954, it was 31.8°C.

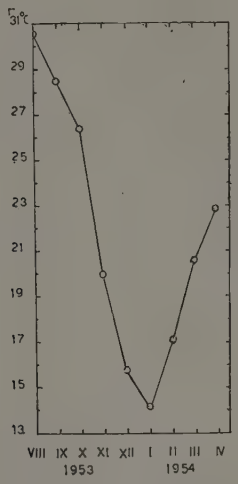

FIG. 6 : The average monthly temperature of August, September, October, November and December 1953, and January, February, March and April 1954.

This is based on the arithmetic mean of the maximum and minimum temperature which gives only an approximate estimate of the true mean daily temperature.

Several egg-pods laid between 10th August and 10th November 1953 were kept continuously in wet soil others on moist plaster. Some eggs were examined at different intervals and their embryonic stages were noted. Results are shown in Table VI.

TABLE VI

Embryonic stages of eggs kept at room conditions in wet soil or on wet Paris plaster and examined at different intervals

Reference number	Number of days from laying	Number of eggs examined	Number of embryos at stages *				
			B	C	D	E	F
1	101–102	257	257	—	—	—	—
2	116–129	168	—	167	—	1	—
3	142–144	136	—	2	—	30	104
4	163–236	222	—	13	—	—	209
5	171–206	239	—	—	—	—	239
6	208–213	147	—	2	—	—	145

* See Figure 1

The outstanding feature of these eggs was the uniformity of development. The first batch of eggs was laid on 3rd and 4th November 1953 and examined on 13th. February 1954, and so it was exposed for a period of 101-102 days to a relatively low temperatures, 20.1, 15.8, 14.2 and 17.1°C. (Figure 6). All embryos were at a preanatrepsis stage (stage B) and showed a uniform appearance with regard to their size and the quantity of amniotic fluid. The second batch of eggs was laid between 30th. September and 13th. October 1953 and examined on 6th February 1954. Almost all embryos were at anatrepsis except one which was at the middle of katatrepsis. It can be observed that this batch of eggs was laid a month earlier than the preceding one and was subjected in October to a relatively higher temperature. The little more advanced development attained by these eggs is certainly a result of being exposed to an average of 26.4°C. during the first month of their life. It has been ascertained that anatrepsis is reached after 16-18 days from laying when eggs were kept at 28°C.

The third batch of eggs was laid between 8th and 10th. November 1953 and examined on 1st April 1954. The mean temperature in March was 20.6°C., and all embryos except two were at katatrepsis. The fifth batch of eggs was laid between 10th September and 15th. October 1953 and examined on 4th April 1954, and it was found that all embryos were at full katatrepsis inspite of the fact that some were examined after 171 days and the others after 206 days from laying. The other batches of eggs, the fourth and sixth, show almost the same point save that a very few number of eggs were still at an earlier stage of development.

The uniformity of development of eggs kept in moist soil at room conditions from the time of laying was shown more clearly when hoppers hatched from some 54 pods kept under these conditions. These pods were laid between 5th September and 31st. October 1953, and all hoppers (1780) emerged between 22nd. and 29th. April 1954 : 216 on 22nd, 808 on 24th., 592 on 25 th., 147 on 27th., 15 on 28th. and 2 on 29th. In June these pods were examined and it was found that all eggs except 34 ones had hatched and those were undeveloped eggs. There was a difference of 56 days between the first and last pod when they were laid and yet all hoppers hatched in a period of seven days at the end of April when the average temperature was 22.9°C. The difference in the incubation period of these eggs was of no importance, and the uniformity of development was a result of being exposed to the same temperatures through out their life. One hundred eggs laid on 29th September 1953 and kept on moist plaster at room conditions were examined after 23 days and they were all found to contain embryos at stage B. On 23rd November, 55 days from laying, another one hundred eggs were examined and they were all found to contain embryos at stage C. Therefore, it can be deduced that embryos in all the eggs which were kept till hoppers emerged must have reached anatrepsis or stage B before the beginning of the coldest month of the year. In these eggs the low temperature of winter months must have had a great influence on breaking diapause.

It is now clear that under room conditions there was no more than one genera-

tion a year. Eggs were laid in autumn, hatched the following spring, hoppers became adults in summer and lay their eggs in the same season or early in autumn. Outdoors, however, there was a higher rate of development. Several egg-tins containing egg-pods laid in the last week of August 1954 were placed in a cage out-of-doors, the soil was kept moist and the temperature was recorded by means of a thermograph. The maximum temperature during the observation period which lasted till hoppers hatched ranged from 31 to 37°C., the minimum from 17 to 21°C. The maximum temperature was reached between 2 and 3 p.m., and the minimum between 4 and 5 a.m. Under these conditions the minimum recorded time for the incubation period was 33 days, and there were hoppers that hatched after 38 and 39 days from laying. It can be deduced, therefore, that in the field *E. plorans* can produce two generation a year.

4. Influence of low temperature on the elimination of diapause

The elimination of diapause is closely associated with low temperature. Diapause may be regarded as an adaptation which preserves the species in a resistant stage during the low temperature of winter and, therefore, it is not surprising that exposure of eggs to adequate low temperature should be one of the effective ways of bringing diapause stage to an end. Other ways to bringing diapause to an end have been practiced by several authors. It is well known that the eggs of *Bombyx* which go into diapause while the embryo is in its early stages of development, will resume development if they are soaked in sulphuric acid of an appropriated strength for certain period (BEDFORD, 1944). SLIFER (1948a) has managed to break diapause in the eggs of the grasshopper *Melanoplus differentialis* by first removing the chorion and then steeping the eggs in xylol for a period of 30 minutes. In both cases the termination of diapause has been brought about by wounding the tissues of the partly developed eggs (ANDREWARTHA, 1952).

In *E. plorans* there is no morphological means of differentiating between diapause and non-diapause eggs. But in *Locustana pardalina*, although all eggs are similar in appearance when they are first laid, yet non-diapause eggs start absorbing water from the 3rd to 4th day, increasing in size and hatch between the 10th and 20th day when left at a constant temperature of 35°C. The diapause eggs fail to absorb water by the 5th day, thus can be differentiated, and hatch unevenly after 36 to 95 days or longer at the same temperature (MATTHÉE, 1951). In *Bombyx* there is a close correlation between egg colour and the presence or absence of diapause. The diapause aggs are characterized by being dark in colour, having the serosa laden with pigments, while the non-diapause eggs are pale (TIRELLI, 1941).

In March diapause was eliminated from the eggs of *E. plorans* after they had been exposed to the low temperatures of winter months (Table VI). The following experiment was designed to study the effect of low temperature on the elimination of diapause when eggs were exposed to 8°C. for 30 days and embryos at different stages of development. Eggs were transferred again to 28°C., kept for 19 days and

then the stages of the embryos were noted. Those which were at anatrepsis were considered to be in diapause. Eggs were kept on moist plaster of Paris, results are shown in Table VII and Figure 7.

TABLE VII

Embryonic stages of eggs kept at 28°C. for different periods, exposed to 8°C. for 30 days and then returned to 28°C. for 19 days

Number of eggs	Number of days at 28°C.	Number of embryos at		Percentage in diapause
		Anatrepsis	Katatrepsis	
15	5	15	0	100.0
157	7	141	16	89.8
25	8	13	12	52.0
73	9	55	18	75.3
118	10	65	53	55.8
50	11	22	28	44.0
134	12	53	81	39.5
86	14	46	40	53.5
270	16	133	137	49.3
40	18	6	34	15.0

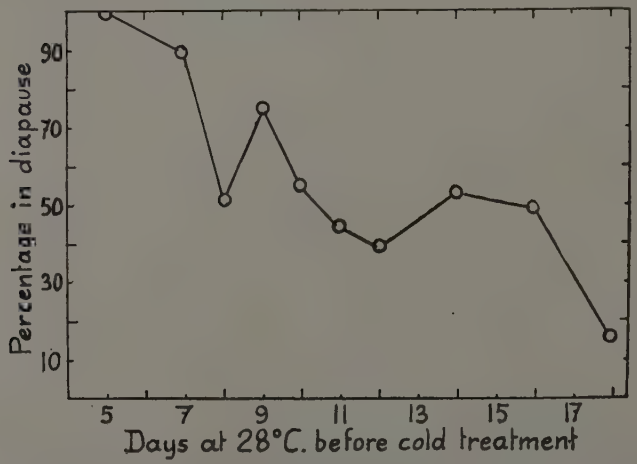

FIG. 7 : Percentage of eggs in diapause when kept at 28°C. for different periods, exposed to 8°C. for 30 days and then returned to 28°C. for 19 days.

It can be observed that exposure to low temperature when eggs were 5 days old and embryos at their early stage of development was almost of no effect on the

elimination of diapause. The sum total exposure to 28°C. was 24 days, 5 days before the cold treatment and 19 days after it, and supposing that at 8°C. no development took place it was found that all embryos were still at diapause stage. It has been shown above that at 28°C. non-diapause embryos undergo the revolving process after 19-22 days from laying. When eggs spent 7 days at 28°C., exposed to 8°C. for 30 days and then returned to warm conditions for 19 days it was found that about 90% were still in diapause. But when the period of exposure to 28°C. was increased, there was a marked decrease in the percentage of embryos undergoing diapause. The Figure does not show a straight line, but it can be observed that when eggs were 18 days old, in other words, when embryos reached the end of anatrepsis they were capable of maximum response when exposed to that constant low temperature for 30 days. Diapause was eliminated in 85% of the eggs. When morphogenesis stopped shorter of this stage this cold treatment was not sufficient to break diapause in almost the majority of eggs. It has been shown that when eggs were kept continuously at 28°C., 84.16% were in diapause; and although this experiment does, by no means, approximate natural conditions of winter months, yet it gives an experimental evidence of the effect of cold temperature on the elimination of diapause in *E. plorans*.

The eggs of *Locustana* undergo no development when kept at 8.5°C., and even when eggs were kept at any of the higher temperatures until the end of katatrepsis before subjecting them to 8.5°C., no further development occurred (MATTHÉE, 1951). In *E. plorans* the exposure to low temperature near the threshold of development had a more profound effect on the elimination of diapause. This has been shown when 14 whole egg-pods containing 237 eggs were placed on wet plaster at 28°C. for 247 days, and then transferred to 16.5°C. for 30 days; they were returned to 28°C. for 19 days. Hoppers that hatched and the embryonic stages of the remaining eggs were noted. The result was compared with some other pods kept at 28°C. for the same total period (Table VIII).

TABLE VIII

A. Percentage of diapause in eggs kept at 28°C. for 247 days, exposed to 16.5°C. for 30 days and then returned to 28°C. for 19 days.

B. Percentage of diapause in eggs kept continuously at 28°C. for the same total period.

	Number of eggs	Number of embryos at		Number of hoppers hatched	Percentage in diapause
		Anatrepsis	Katatrepsis		
A	237	34	87	116	14.35
B	139	135	4	—	97.12

The temperature of 16.5°C. is presumably higher than the threshold of development of *E. plorans* eggs as in most acridid eggs this lies between 10 and 15°C. At

a lower temperature, 8°C., morphogenesis ceases almost completely but physiological processes (physiogenesis) still goes on as embryos resume development almost completely on return to warm conditions. When eggs had been exposed to 16.5°C. diapause was eliminated from most of the eggs as embryos grew and physiogenesis took place at a quicker rate. This was shown by the fact that one hopper was found while pods were at 16.5°C. and severals started to emerge on return to warmer conditions.

VII. THE PERMEABILITY OF THE HYDROPYLE

When the egg is laid it is enclosed by two envelops, the chorion and the vitelline membrane. Later in development the serosal cells which are beneath the vitelline membrane secrete the serosal cuticle which comprises the yellow and white cuticle. The latter is generally thick and is responsible for the toughness of the grasshopper egg. When an egg is about to hatch the serosal cuticle is partly digested and absorbed, and at the end of this process an empty egg-shell is composed of only the chorion and the yellow cuticle. The coverings of the egg protect it from the loss of water by evaporation, and it has been shown by MATTHÉE (1951) in the egg of *Locustana pardalina* and by SLIFER (1948b) in the egg of *Melanoplus differentialis* that a lipoid material, the primary wax layer, is secreted by the oocyte before ovulation and is deposited as a continuous film on the inner surface of the chorion.

In *E. plorans* newly laid eggs were highly resistant to the entrance of iodine. When eggs were immersed in iodine solution the chorion was found to stain deeply, but the primary wax layer on the inner surface of the chorion prevents the iodine from passing through the vitelline membrane into the yolk. This resistance to the penetration of iodine correlates with the fact, already mentioned, that the eggs do not absorb water or increase in weight during the first one or two days from oviposition when kept in moist sand at 38°C. After the first or second day this wax layer is removed or in some way still unexplained breaks down, loses its continuity or disorganized and the eggs start to absorb water and increase considerably in weight. From the third day the serosal cuticle with its specialized area, the hydropyle, are being formed, and from then till the seventh day the resistance of the egg to iodine drops sharply, the hydroplyle is stained and yolk is coloured brown. This corresponds to the fact that eggs increase considerably in weight and their water content increases sharply from the third to the seventh day (Fig. 4).

In *Locustana* and *Melanoplus* when the serosal cuticle is secreted and the primary wax layer is removed the chorion is rendered again waterproofed by the secretion of a secondary wax layer being deposited by the serosal cells between the yellow and white cuticle. The egg-membranes are now highly impermeable except at the region of the hydropyle. But some of *E. plorans* eggs which completed anatrepsis on the 10th day at 38°C. or on the 16th-18th day at 28°C. were most resistant to iodine. The hydropyle in these eggs was rendered, therefore, waterproofed. It

has been shown by the above mentioned authors that a proteinwax secretion produced by the serosal cells accumulates on the outer surface of the hydropyle in those eggs which entered diapause in *Melanoplus* and in the quiescent eggs of *Locustana*. In diapause eggs of *Melanoplus* this water proofing material prevents the additional water required to complete embryonic development from entering. When diapause ends the hydropyle becomes again permeable, water is taken in and development is resumed.

The permeability of the hydropyle in eggs of different species of grasshoppers of known embryological stage has been tested using iodine solution.

1. Euprepocnemis plorans

(A) The result of examining 50 eggs kept on wet plaster of Paris at 28°C. after 125 days from oviposition was as follows :

2. eggs had the hydropyle and the egg-contents stained (stage of embryo: katatrepsis): 11 eggs had the hydropyle stained and the egg-contents unstained, while in 37 other eggs the hydropyle and the egg-contents were found unstained (stage in both : anatrepsis).

(B) The result of examining 57 eggs kept on wet plaster at room condition after 140 days from oviposition was as follows :

30 eggs had the hydropyle and the egg-contents stained (stage of the embryo: katatrepsis); 5 eggs were found with the hydropyle stained and the egg-contents not stained (stage of embryo: mid-katatrepsis); 21 eggs had the hydropyle stained and the egg-contents unstained, while in another egg both the hydropyle and egg-contents were found stained (stage of embryo in both : anatrepsis)

The conclusions which can be drawn from these observations are : (1) at 28°C. the majority of eggs had the hydropyle waterproofed as it retained its natural colour, these eggs were undergoing diapause; (2) in those eggs which had stained hydropyles but their contents were intact diapause was apparently coming to an end; (3) when embryo was at katatrepsis the hydropyle was permeable and egg-contents were equally stained.

The second batch of eggs was kept at room conditions and examined on 28th March 1954, and it was found that : (1) the majority of eggs had completed development and about to hatch, the hydropyle and egg-contents were equally stained; (2) in 21 eggs (36.8%) the embryo was still at anatrepsis but diapause was apparently coming to an end, hydropyle stained but egg-contents intact; (3) in one egg the hydropyle was permeable and egg-contents stained while embryo at anatrepsis; in this case the waterproofing material must have been removed earlier than in the preceding batch; (4) in 5 eggs (8.8%) the hydropyle was stained, egg-contents intact while embryo at midkatatrepsis; the reason for this is not easy to explain. It may be that the stain had not yet reached the embryo because of the existance of waterproofing material on the inner side of the hydropyle. In this case, therefore, the

completion of blastokinesis must have taken place without the absorption of any further amount of water. This phenomenon is, however, not clear and needs further investigation.

2. Aiolopus thalassinus

40 eggs kept on wet plaster at room conditions from 3rd November 1953 till 28th March 1954 (145 days) were examined. The hydropyle and egg-contents were stained and embryo was at katatrepsis.

3. Aiolopus savignyi

32 eggs kept on wet plaster at room conditions from 11th November 1953 till 28th March 1954 (137 days) were examined. The hydropyle and egg-contents were stained and embryo was at anatrepsis.

4. Thisoicetrus littoralis

50 eggs kept on wet plaster at room conditions from 23rd November till 4th March 1954 (101 days) were examined. The hydropyle and egg-contents were stained and embryo was at katatrepsis.

It can be observed that in these grasshoppers the hydropyle was permeable and egg-contents were discoloured while embryo was at katatrepsis in *A. thalassinus* and *Thisoicetrus*, and at anatrepsis in *A. savignyi*. The latter species does not go into diapause and eggs are ready to absorb water and develop whenever favourable temperature and moisture are available.

VIII. DISCUSSION

Among insects and other arthropods no species are closely dependent for at least the development of eggs on soil moisture as those which lay their eggs in the soil. Between soil particles the spaces are filled with either free water or with air saturated with water vapour. Such conditions are generally most favourable for the development of eggs provided temperature is at the optimum level. The Acridid egg is ecologically and physiologically adapted to live and develop in its environment. If free water is available egg membranes can absorb it and embryo develop. In its absence the eggs of some species can secure it from the atmosphere; in others the chorion can resist desiccation by a certain waterproofing mechanism, and the embryo remains till better conditions take place.

In Acridiidae it is possible to recognize three different types of insects with regard to embryonic development. The first type lays eggs all of which develop at a constant rate without any break in their embryonic development. *Schistocerca gregaria* is an example of this type; it has been shown by SHULOV (1952) that the

eggs are able to develop at 20-33°C. if during 3-5 days following oviposition they were in contact with water. Eggs were able to absorb atmospheric humidity when exposed to 90-100% R.H. at 27-30°C. Anatrepsis was attained by most embryos but they all failed to hatch. Eggs which were in contact with water for 3 days at 27°C. were able to develop when exposed to 40-100% R.H. At the drier end of the scale the egg is liable to lose some of its water. Development can proceed without absorbing water up to the stage of late anatrepsis, but for its completion water must be absorbed. If water is not provided within 15-20 days, the embryo dies. It has been reported by HUSAIN, AHMAD and MATHUR (1940) that eggs of *S. gregaria* can remain alive in dry soil for 81 days and resume development when the soil was moistended. BALLARD, MISTAKAWI and ZOHEIRY (1932) recorded a long interruption due to cold and slow rate of development when eggs of *S. gregaria* were placed under natural conditions; an incubation period of 106 days was recorded for eggs deposited in November.

The eggs of *Nomadacris septemfasciata* (FAURE, 1935), *Locusta migratoria migratorioides* (HAMILTON, 1936) and *Chortoicetes terminifera* (ANDREWARTHA, 1945) fall in this category. In nature the adults of the first two species may remain sexually immature throughout the dry season and undertake oviposition only after the onset of the wet season. This has been called an imaginal diapause, but it has been shown by SHULOV and HAMILTON that these locusts can breed continuously under controlled laboratory conditions and a certain degree of relative humidity is essential for sexual maturation.

The eggs of *A. thalassinus* and *A. savignyi* develop also at a constant rate without a break in the embryonic development, provided they are exposed to favourable conditions of temperature and moisture. Moreover, they were able to absorb the required amount of water to complete development from an atmosphere saturated with water vapour. When eggs were kept in contact with water for different periods from laying they were able to hatch not only at higher humidity at which water equilibrium was reached but also at lower humidities at which they were liable to lose some of their water. It has been shown that in *A. thalassinus* the degree of relative humidity at which an equilibrium can be maintained in newly laid eggs (that humidity at which water is neither gained nor lost by eggs) lies in the close range of 95 and 100% R.H. Eggs at 100% R.H. absorbed water, increased in weight, their embryo developed, although at a slower rate, and hoppers hatched; but those at 95% R.H. shrivelled up, lost weight and died. The percentages of hatching when eggs were kept for 9, 10, and 12 days in contact with water and then exposed to 45% R.H. were 16, 18 and 66% respectively. At this degree of relative humidity newly laid eggs and those kept in contact with water for 5 days shrivelled up, lost weight and died. It is most likely that when eggs kept in contact with water for 9 days, and at this period anatrepsis was reached, they must have absorbed all water needed for further development and perhaps more to offset the effect of desiccation. In eggs of *E. plorans* kept in moist sand at 38°C. the moisture content increased rapidly from the second till the seventh day from laying when the stage of anatrepsis was reached.

There was an almost complete cessation of water absorption (since the moisture content remained at a constant level) in the following period. There was, however, a slight increase in water content when non-diapause eggs were about to hatch (Fig. 4). It has been stated by BROWNING (1953) that in most eggs that have been studied the period of rapid water uptake occurs either before the eggs enter diapause or is delayed until after diapause is complete; and it is known that certain species of grasshoppers undergo diapause at the stage of anatrepsis. In the latter case the absorption of water is merely incidental and serves as an aid for healthy post-diapause development (ANDREWARTHA, 1952). The eggs of *S. gregaria* increase slightly in weight on 18th day when eggs were about to hatch (BALLARD ET AL., 1932); but SHULOV (1952) records a continuous increase till the stage at which the embryo is ready to hatch.

It has been shown that in *A. thalassinus* a 45% R.H. was the minimum level for hatching when eggs, kept in contact with water for 9-12 days, were exposed to a gradient of relative humidity at 28°C. In the field the soil spaces are always filled with either free water or air of 100% R.H. The water table is the permanent source of water vapour. But in an egg-tin when eggs, kept in contact with water for 5 or 7 days, were embedded in sun-dry soil they all shrivelled up and died. This shows that under this condition the relative humidity of the air in the soil spaces must be much below the saturated point.

Lastly, it has been stated by ANDREWARTHA (1945) that there was no diapause in the eggs of two Australian species of grasshoppers, viz., *Chortophaga viridifasciata* and *Cerphia sulphurea*. With these species the nymphs emerge in the summer shortly after the eggs are laid, they grow during the summer and hibernate either as fifth instar nymphs or adults.

The second type of Acridid insects lays eggs some of which develop at constant rate without a break in their embryonic development (non-diapause eggs), and others which must pass through a resting stage (diapause eggs). *Melanoplus differentialis* (SLIFER 1932, and BURDICK 1937), *M. mexicanus* (PARKER, 1930), *Locustana pardalina* (MATTHÉE, 1951) and *E. plorans* are representatives of this category. In *M. differentialis* the incubation period of non-diapause eggs ranged between 32 and 44 days, and the mean incubation period of diapause eggs was 150 days when exposed continuously to 28°C. Diapause usually occurs in 30% of the eggs. With *M. mexicanus* when eggs were exposed continuously to 27, 32 and 37°C. the mean incubation periods were 26, 32 and 46 days respectively, and the percentage of eggs that passed through diapause at each temperature was 55, 60 and 63%, respectively. Even at these temperatures the diapause factor is still evident, chiefly by the fact that a longer time was necessary for development at 37°C. compared with 27°C.

In *Locustana pardalina* eggs develop, whether moistened or kept dry from the time of oviposition, to the stage of anatrepsis. Some eggs enter a state of diapause, as favourable conditions of moisture and temperature will not initiate further growth and take 36-95 days or longer to hatch if kept continuously under favourable develop-

mental conditions. Non-diapause eggs will hatch in about 14 days when incubated at 35°C. and kept continously wet. But if they are kept dry a quiescent period will occur and on moistening development will be resumed. In *E. plorans* there were three different ranges of the incubation period when eggs were kept at 28°C. There were eggs that hatched in 40 days and others that took more that 259 days to hatch. It has been estimated that about 80% of the eggs underwent diapause at varying intensities.

The third type of Acridid insects lays eggs all of which undergo diapause and they are unusually uniform in the intensity of the diapause which is present. The Australian grasshopper *Austroicetes cruciata* is a representative of this category (ANDREWARTHA, 1943). There is only one generation a year, and when eggs were exposed to high temperatures (30°C.) development was almost completely inhibited. It has been stated by Andrewartha that the occurrence of diapause appears to be of paramount importance to the survival of the species, since the diapause period coincides with the dry summer months when eggs are usually subjected to dry and warm conditions. Eggs in diapause are more resistant to desiccation than non-diapause eggs and, therefore, have a much better chance of survival.

Diapause was eliminated from the eggs of *A. cruciata* by exposing the eggs (preferably alternately) to low (5-13°C.) and high (17-33°C.) temperatures until the embryo reached the end of anatrepsis. At this stage the egg is capable of maximum response when exposed to constant low temperature. When *M. differentialis* eggs were exposed shortly after being laid (before reaching the diapause condition) to low temperature the diapause was prevented, and on return to a suitable high temperature (28°C.) development proceeded without interruption (BURDIC, 1937). In *E. plorans*, however, diapause was eliminated in most of the eggs when exposed to low temperature while the embryo was at the end of anatrepsis. Shortly after eggs being laid exposure to cold conditions was almost of no effect on diapause elimination.

IX. SUMMARY

1. — In locusts and grasshoppers the development of eggs is closely dependent on soil moisture and the relative humidity of the air in the soil spaces. In *E. plorans* eggs cannot develop beyond a certain stage, prior to anatrepsis, when kept at 80-100% relative humidity and that contact with water is essential for further development. In *A. thalassinus* and *A. savignyi* eggs are able to absorb the required amount of water to complete development from an atmosphere saturated with water vapour.

2. — When *E. plorans* eggs were deposited in wet soil in summer or autumn and kept under room-conditions they were able to absorb their water requirement and hatch in the following spring. But when deposited in dry soil embryos can develop to a stage near anatrepsis, remain alive for nearly a year and resume development when water is availabe. Water absorption and the increase of weight occur chiefly during the process of anatrepsis.

3. — *E. plorans* lays two types of eggs : diapause and non-diapause eggs. At 28°C. nearly 80 % of the eggs undergo diapause when the embryo reaches anatrepsis at varying intensities. The incubation period may be anything between 69 and 259 days and perhaps longer. At the same temperature non-diapause eggs usually hatch in 40-60 days.

4. — Diapause was eliminated from most of *E. plorans* eggs when exposed to 8°C. for 30 days while the embryo was at anatrepsis.

5. — At 38°C. and in *E. plorans* the egg-chorion is permeable to iodine solution from the third to the seventh day, the hydropyle and yolk is stained brown. But during diapause the chorion and hydropyle are perfectly waterproofed. When diapause comes to an end the hydropyle is rendered permeable and egg-contents are equally stained.

6. — In *A. thalassinus* and *A. savignyi* there is no diapause and the hydropyle is able to absorb water during all stages of embryonic development.

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FURTHER ADDITIONS TO THE COCCOIDEA OF EGYPT

[*Hemiptera-Homoptera*]

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INTRODUCTION

This paper represents a brief report about three species of *Coccoidea* new to Egypt, and a note about a fourth one that has probably been inadequately identified.

Acknowledgment is due to Dr. W. J. HALL of the Commonwealth Institute of Entomology, as well as to Dr. H. MORRISON of the United States Department of Agriculture, for their kind effort in identifying the material sent to them. Meanwhile, credit should be given to the Egyptian Entomologists, S. HOSNY and A. MADKUR, for making the initiative collecting.

The species under consideration will appear, in the following paragraphs, in alphabetic arrangement. Each paragraph is supplemented with a short differentiating diagnosis.

Eriococcus coccineus Cockerell (Kermidae)

This species was collected in May 1948, on a cactus plant (*Cereus flagelliformis*), at the Palace Gardens in Inshas. At that time of the year, the specimens were all in the young stages; but in July, more specimens were examined and found to include both adult females and male puparia. The males were found mounted on the tips of the thorns which covered the whole plant, and were very conspicuous with their snowy white cocoons.

The only other species of *Eriococcus* known to occur in Egypt is *E. araucaria* Maskell, which may look similar to *E. coccineous* Cockerell in having a 7-jointed antenna. However, *coccineus* could be readily differentiated by having the stout blunt

setae of the margin arranged in a continous wide row, about two to four setae wide; dorsum carries similar setae, arranged in a pair of submedian rows on the cephalothoracic region; and posterior coxae are without translucent pores.

Lepidosaphes pallida (Green) (Diaspididae)

This scale was discovered in Egypt in April 1947, on mango trees (*Mangifera indica* L.), at the Barrage, close to Cairo. It was very common on the leaves, and the male puparia were quite abundant. In 1950, it was collected from Upper Egypt at Wadi Comombo. Recently, in 1955, it was collected from Ein Shams, a suburb of Cairo. Finally, in August 1956, samples were obtained on leaves of guava trees (*Psidium guajava* L.) from Nag Hamadi.

This species is similar to both *L. ulmi* (Linnaeus) and *L. gloverii* (Packard) in having lateral spurs on the prepygidial abdominal segments. However, *pallida* differs from *ulmi* in having one or two dorsal ducts only on the sixth abdominal segment; and few perivulvar pores, the median group of which is arranged in a short single row. On the other hand, *pallida* differs from *gloverii* in the membranous appearance of its thorax and first abdominal segment; and the dorsal ducts on the first to the fifth abdominal segments are not arranged in segmental rows but in small submarginal and submedian groups.

Lindingaspis floridana Ferris (Diaspididae)

This scale insect was collected in June 1943 for the first time in Egypt, on mango at Gaafariah, Sharkiah Province. The scale was wholly confined to the leaves, and most of the specimens were male puparia while adult females did not exceed 30% of the population. In 1955, this species proved to be present also in Ein Shams, a suburb of Cairo.

In this case, the whole genus *Lindingaspis* MacGillivray is new to Egypt. The pygidial paraphyses and serrate margin of this genus are more liable to attract attention towards the genus *Chrysomphalus* Ashmead. However, the paraphyses in Lindingaspis are present also anterior to the position of the fourth lobes; and the series of tooth-like marginal projections that give the pygidial margin a serrate appearance extend up to the position of the marginal seta which marks the fifth abdominal segment.

NOTE

In 1926, HALL published about the appearance of *Eulecanium berberidis* Schr. in Egypt, on the small branches of Mulberry, *Morus alba*. Moreover, HOSNY published in 1943 that this species is also infesting the grape vines, *Vitis vinifera* and quoted HALL that this species is similar to *Eulecanium persicae* but differs in the character of the marginal hairs being long and setiferous instead of being short and

spiniform, and that *berberidis* has submarginal series of large conspicuous tubular ducts. Later on, in 1945, the *Review of Applied Entomology*, XXXIII, Ser. A, pp. 227-228, reported that *Eulecanium persicae* Fabr. (*berberidis* Schr.) was found in Egypt, i.e. considering *persicae* and *berberidis* as synonyms.

In 1947, a coccid was collected on branches of plum from Geziret Dabsha, near Helwan. The infestation was so heavy that the branches were almost completely covered with the hard bodies of these naked scles. It was identified as *Eulecanium* spec. (Family *Coccidae*), and thought to be a newr ecord to Egypt; but when examined by Hall, and then by Morrison, they decided to consider it as *Eulecanium persicae* Fabr. until the members of this group are studied in relation to each other.

A comparison made by Dr. A. Habib, of Ein Shams University, Egypt, between the material previously declared in Egypt as *berberidis* and the material sent to Hall and Morrison and considered *persicae*, did not show any significant difference between the two lots. Therefore, this coccid is going to be known here as *persicae* for the time being.

SUMMARY

This paper records the discovery of three species of *Coccoidea* for the first time in Egypt. These species are : *Lepidosaphes pallida* (Green) and *Lindingaspis floridana* Ferris from the family *Diaspididae*, and *Eriococcus coccineus* Cockerell from the family *Kermidae*.

The paper is tailed by a note discussing the existance of *Eulecanium persicae* Fabr. in Egypt.

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HELEIDS FROM IRAQ, WITH DESCRIPTION OF NEW SPECIES

[*Diptera* : *Heleidae* (*Ceratopogoninae*)]

(with 11 Text-Figures)

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This study is concerned with the genus *Culicoides*. The insects were collected by electric light through the use of either a white sheet and aspirator or an opaque funnel placed at the mouth of a killing jar. The light was usually operated in the first half of the night.

In Baghdad, the trap was operated in the various sections of the city for about ten well-spaced nights per month, in 1955 for April and in 1954 for May, June, and July. Sporadic collections in the same two years, in other than these nights were also secured. About seven hundred specimens of *Culicoides* were collected. They represent six species. *C. schultzei* was the most abundant, followed by *C. puncticollis* and *C. pallidus* nov. spec.. *C. micromaculithorax* nov. spec. was less abundant, while the remaining two species were rare.

In Shaklawa, the trap was operated in August, 1954 in nine selected nights between the fifth and the twenty third. 116 specimens of four species were collected. *C. odibilis* and *C. shaklawensis* nov. spec. were rare in the collection.

In Amarah, the trap was operated in July and September, 1955, and in Mosul in four nights in the first half of August, 1955.

Iraq is very interesting from the zoo-geographical standpoint. It falls in a transitional area where the Palaearctic sub-region meets both regions the Oriental and the Ethiopian. The fauna that it contains, therefore, has relation to the faunae of the three divisions just mentioned. This is true when the distribution of some species of the genus *Culicoides* is studied. It contains species which belong to the three divisions.

I wish to express my gratitude to Dr. KHALID EL-HASHIMI, Dean of Higher Teachers' College, and to Professor M. ABDEL JABAR, Head of the Department

of Biology, for offering the facilities for this project. I am very thankful to KH. NAKSHBANDI, S. MUSTAFA, and H. ABDEL MALEK, students of the Biology Department, for the assistance in the preparation of the figures.

C. puncticollis Becker

Large species. Mesonotal pattern of the dotted type. Wing mostly white with dark areas. Single, bent spermatheca. Parameres not completely split. Terminal portion of the aedeagus has a longitudinal median cut.

FEMALE : The largest species of the genus in Baghdad. Dark brown. Mesonotum with grayish pruinescence. The dots are located at the bases of very fine short hairs. Dark patch in the middle of the scutellum includes light spot. Halteres whitish. Abdomen dark brown. Legs and antennae of a much lighter color.

In the wing, the macrotrichia well represented. Most of the light milky areas are not well defined. There are three costal dark spots : near base before r-m cross-vein, on the second radial cell, and at about the middle of cell R_5. This last spot has a small accessory spot behind it. There is a faint dark spot at tip of cell R_5. Other dark spots are located as follows : in about the middle of cell M_1, in the middle of cell M_2, in the middle of cell M_4 connected to a dark area behind it bordering vein Cu1, and in the middle of the anal cell. Kness dark, legs of the banded type. Eyes well separated. Last five segments of the antennal flagellum little shorter than the first eight. Each one, except the terminal, of about the size of any of the rest of the segments of the flagellum. The last segment is much longer. Third segment of the palpi somewhat longer than the second, moderately swollen, with moderate sensory pit. Fifth segment noticeably longer than the fourth. The single spermatheca is elongated, bent vesicle.

MALE : Hypopygium apico-lateral processes well developed and divergent. Sternite almost not concaved. Dististyle with tapering end. Basistyle has both ventral and dorsal process which are about equally developed. Arch of the parameres unsplit, terminal portion bifurcate. Terminal portion of aedeagus with a longitudinal median cut. This portion is joint from both sides by membrane to the arch of the aedeagus.

It had been collected in Baghdad between April 4th and July 22nd. One female was caught in 1955 on each of March 23rd and January 13th. One female was also found in Shaklawa in August 23rd, 1954.

This species has a wide distribution and it has already been reported from the Middle East and Baghdad (EDWARDS et AL, 1939).

C. schultzei (Enderlein)

Mesonotal pattern of the dotted type. Wing spots very distinct. Just beyond the second radial cell there are two light spots, one behind the other, and another before the tip of cell R_5. Membrane spinose. Terminal portion of aedeagus short and truncate. Parameres slender, their tapering end long and with faint serration.

FEMALE : Small species. Mesonotum brown with greyish pruinescence, the two colors forming a pattern of the dotted type. The brown dots around the bases of the mesonotal hairs. There are one median and two lateral rows of small dots. Between the lateral and the median row there are larger dots interrupted in the prescutellar depression by a large spot of dark pruinescence behind which is a large dot. Outside of the lateral row there is another row of a little larger dots, the anterior part of it forms part of an anchor shaped brown figure. There is a brown spot in front of the humeral pit and to the side of this the humeral angle is brown. Rarely the brown dots appear confluent or not very distinct and the pattern is then similar to the spotted-striped type. Scutellum greyish with brown center. Halteres whitish. Metanotum dark brown with greyish center. Abdomen darker brown. Proboscis and palpi brown. The antennal flagellum little lighter. Macrotrichia present in the upper half of the wing, especially in cell R_5. Wing spots quite distinct. Second radial cell included in a dark spot. Light spot just beyond second radial cell. Behind the upper part of this, is another one in cell R_5. Beyond these two light spots is a distinctly dark area and beyond this is a bilobed light spot before the apex of cell R_5. There is a light, less apparent strand behind the second radial cell which joins a spot that starts in the costa and covers r-m cross-vein and does not cross the median vein. Cell M_1 with light spot near tip and another in the middle. Veins M_1 and M_2 with light borders, cell M_2 with a light spot at tip and another at median fork just behind the spot on the cross-vein. Light spot in front the medio-cubital fork. Light spot in cell M_4 crosses that cell parallel to vein cul. Vein M3+4 with light border near tip. Vein Cul with light border that extend less distinctly down the medio-cubitus to join the light area at the base of wing and near the base of anal cell. Anal cell with light spot near tip too. Legs brown. Knees darker with light bands above and below. Also light bands at bases of femora and apices of tibiae. Eyes separate, black, darker than the rest of the body. Last five segments of the antennal flagellum well enlarged and little longer than the first eight. Of the palpi, third and second segments subequal, third moderately swollen with a deep pit. Fifth segment little longer than fourth. There are two spherical spermathecae each of about 45μ. Base of duct sclerotized for a short distance. The rudimentary spermatheca long (about 22 μ). Ring, of about 10 μ, present.

MALE : Hypopygium apico-lateral processes well developed and divergent. Ninth tergite narrowed distally. Ninth sternite concaved. Membrane ventral to the aedeagus spinose. End of dististyle, not foot-shaped. Ventral and dorsal processes well developed. Parameres slender, with knob-like end to the base, the stem somewhat swollen, tapering end long, bent and with faint serration. The aedeagus with high arch and short, truncate terminal portion which is nearly of the same width throughout.

C. schultzei was caught in Baghdad between April 4th and August 5th. Few specimens were collected in September 10th and October 19th. It had been also

collected from Amarah in the first week of July, 1955, and from Mosul in the first half of August, 1955.

CARTER et AL (1920) showed the dotted-type mesonotal pattern of this species and the spinose membrane of the hypopygium. Their description for the scutellum, halteres, and legs also agree with the Iraqian specimens. Their figure of the wing shows more definite boundaries to some of the spots. They state, however, the presence of variation in this respect. The main differences from our specimens are found in their figure of the hypopygium. They showed : (1) few fine hairs at the extreme tip of the parameres while such hairs in our material extend to the terminal portion, (2) the terminal portion of the aedeagus shorter than it is in our specimens. MACFIE (1943) stated that this species is very variable in size, color, and the details of the adornment of the thorax and wings. Variability in the mesonotal pattern may be the effect of handling. He describes three pale spots (not two) just beyond the end of the costa. The third spot may be the remains of the light area behind the dark spot. MACFIE (1937, 1943) reported that *C. oxystoma* Kieffer (1910) apparently does not differ in any essential respect from the African species *C. schultzei* (ENDERLEIN, 1908). The description of CAUSEY (1938) for the hypopygium of *C. oxystoma* fits the Iraqian material except that he did not show the spinose membrane or the fine short hairs at the distal portion of the parameres. He mentioned the dotted type mesonotal pattern and the presence of variation in the wing markings (see also MACFIE 1941, SMITH and SWAMINATH 1932). EDWARDS (1922), working on *C. oxystoma*, states that the sclerotized neck of the spermathecae is rather long which disagrees with our specimens. Also SMITH and SWAMINATH (1932) reported minute accessory spermatheca, while the rudimentary spermatheca in our material is about 22 μ. long. TOKUNAGA (1937) showed the fine hairs of the parameres of *C. oxystoma* which resemble the case in our material. In his figure, however, the distal end of the parameres was more tapering, and the processes of the basistyle were less developed than in our material. JOHANNSEN (1931) describes the halteres of *C. oxystoma* as being blackish at tip. This is not the case in our material. The discoloration could be artificial. VARGAS (1949) summarised the synonymy of *C. schultzei*. The species that he accumulated were *C. oxystoma*, C. *kingi* Austen, *C. kiefferi* Patton, and *C. pattoni* Kieffer. The synonymy of the last two species was mentioned by TOKUNAGA (1937). From the figure given by PATTON (1913) for *C. kiefferi*, this species seems to resemble our species. The median dark band of the thorax could have resulted from the destruction of the grey pubescence from between the dots. PATTON (1920) described a new species (*C. mesopotamiensis*) from Khamisiyah (Iraq). From the wing characters of his figure this species also is most probably *C. schultzei*. He mentioned that the thorax is without any distinct markings.

C. pallidus nov. spec.

Light colored species. Mesonotum without distinct pattern. Wings clear. Processes of the basistyle well developed and sclerotized, the ventral is boat-hook

shaped. Terminal portion of aedeagus short, slender and roughened. Parameres almost straight, tapering end bent and faintly spinose.

FEMALE : Species of moderate size and light color. Thorax light brown or yellowish brown. Mesonotum without distinct pattern. Scutellum yellowish. Halteres with yellowish stalk and whitish knob. Abdomen yellow or greenish. Wings clear and with yellowish tinge. Macrotrichia well distributed except near base. Legs yellow, not banded. Knees not dark although they sometimes show traces of darkness. Eyes black, approximate in front, but not touching. Last five segments of the antennal flagellum elongated and about equal to the first eight. Third segment of the palpi much longer than the second, well swollen, and with a deep pit. Fifth segment longer than the fourth. There are two oval spermathecae (55-60μ). Base of duct sclerotized for a short distance (5μ). There is a narrow rudimentary spermatheca (22 by 4 μ). Ring present, 10 μ long.

MALE : Hypopygium (Fig. 1) apico-lateral processes moderately developed, nearly parallel. Ninth tergite truncate, posterior margin not indented in the middle. Ninth sternite with shallow concavity. Ventral processes shaped, very strongly

FIG. 1: Male hypopygium of *Culicoides pallidus* nov. spec., ventral view.

like boat-hook, and the hook is barbed. Dorsal processes well developed. Both kinds of processes well sclerotized. The bent part of the base of the parameres very short, the stem little swollen, the tapering end long, bent and with numerous fine hairs. The sides of the arch of the aedeagus long and slender, the terminal portion slender and roughened.

HOLOTYPE (male), Baghdad, September 10th, 1954, in the British Museum. It had been collected in Baghdad between April 4th and August 5th. The species was not so conspicuous in May. Two males were collected in September 10th, 1954. It had also been caught in Amarah in July 9th, 1955.

C. mosulensis nov. spec

This species is very closely allied to the more southern species *C. pallidus*.

Mesonotum brownish yellow. The humeral angles, scutellum, abdomen, and legs yellow. Eyes black. Antennae, palpi, and spermathecal apparatus are like those

of *C. pallidus*. Last five segments of the antennal flagellum subequal with the first eight. Last segment narrowed distally. Length of the long axis of the oval spermathecae is 50 μ. Eyes are also approximate but not touching.

MALE hypopygium (Fig. 2) resembling that of *C. pallidus*. Important differences are as follows : terminal portion of the aedeagus broad and truncate, sides of the arch not as slender; in the parameres, the knob of the base more pronounced,

FIG. 2: Male hypopygium of *Culicoides mosulensis* nov. spec., ventral view.

the end not that stout but more tapering, the spines more conspicuous; ventral processes of the basistyles boat-hook shaped, but this shape less distinct than in *C. pallidus*, the dorsal processes are shorter and broader.

HOLOTYPE (male), Mosul, August 5th, 1955, in the British Museum; ALLOTYPE (female), Mosul, August 13th, 1955, in the British Museum.

This species was collected from Mosul in the first half of August, 1955.

C. mosulensis could be very closely related to *C. citrinellus* Kieffer which was described from Algeria in 1923.

C. micromaculithorax nov. spec.

Mesonotum with pattern of the dotted type. Wings clear. Three spermathecae. The ends of the parameres and the terminal portion of the aedeagus highly pigmented.

FEMALE : Small species. Mesonotum brown with grayish pubescence. The pattern may be said to be of the dotted type, but it is peculiar because of the smallness of the dots. The dots are at the bases of small hairs. There is a median line of dots and a lateral one on each side of it that starts from the medial side of the humeral pit. Between the mid- and lateral lines there are scattered small dots. There are dots in the area outside the lateral line. Under proper illumination a brown spot could be seen behind the humeral pit. Scutellum yellowish. Halteres whitish. Abdomen brown. Proboscis brown, antennae yellowish.

Wings clear. Macrotrichia well represented except at the base of wing. Legs yellowish. Knees dark with light band above and below. Eyes black and separate. Last five segments of antennal flagellum about equal to first eight. Third segment of the palpi longer than second, well swollen and with shallow pit. Fifth segment little longer than fourth.

There are three spermathecae, each about 30 micra in diameter. Base of duct not sclerotized, so the spermatheca appears like an egg opened from one side.

MALE : Hypopygium (Fig. 3) apico-lateral processes well developed, long and slender, and nearly parallel. End of ninth tergite very slightly notched. Ninth sternite not emarginate. Slender part of dististyle long, end not foot-shaped. Ventral and

FIG. 3 : Male hypopygium of *Culicoides micromaculithorax* nov. spec., ventral view.

dorsal processes of basistyles well developed. Parameres of about the same width throughout; base knobed; tapering end short, little bent, and very well sclerotized so it appears distinctly dark. Aedeagus with high arch. There is a membrane joining the sides of arch at the distal end. Terminal portion short and tapering, and very well pigmented like the ends of parameres.

HOLOTYPE (male), Baghdad, August 5th, 1954, in the British Museum; ALLOTYPE (female), Baghdad, June 24th, 1954, in the British Museum.

It had been collected in Baghdad between April 4th and September 10th. The species was not so conspicuous in April and May. It was also found in Mosul in the first half of August, 1955.

This species is similar to *C. albipennis* which was described originally from Assam by SMITH and SWAMINATH in 1932 (MACFIE 1937, stated that the name *C. albipennis* is preoccupied. It was used by KIEFFER in 1901 and 1925 for a European species). In the Iraqian species the color is not light; the macrotrichia are better represented, they are found even in the anal cell. The macrotrichia, however, can be detached easily. The main difference is found in the hypopygium, in the aedeagus and the parameres. In the aedeagus of *C. micromaculithorax*, the terminal portion is pointed (not truncate), and there is a narrow membrane joining the sides of the arch. The distal end of the paremeres is bent in the opposite direction. In addition to that, SMITH and SWAMINATH, on describing *C. albipennis*, did not mention highly sclerotized terminal portions of the parameres and the aedeagus.

C. similis baghdadensis nov. subspec.

Pattern of mesonotum of the indistinct type. Among the spots of the wing, one at tip of cell R_5. Stem of parameres carrying distally a knob; tip bent and strongly spinose. Terminal portion of aedeagus long and tapering.

FEMALE : Light colored species. Mesonotum light brown, pattern of the indistinct type. There is a somewhat crescent-like brown spot on each side near middle. Such coloration is found around the humeral pit and the periphery. Scutellum

yellowish. Halteres whitish. Abdomen of a lighter color than the mesonotum (yellowish). Appendages of the head of a light color.

Macrotrichia well represented and distributed except in cell R and the basal part of cell M_2. Second radial cell included in a dark spot. Light spots (Fig. 4) at

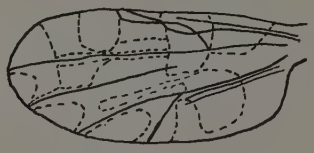

FIG. 4: Wing of *Culicoides similis baghdadensis* nov. subspec. showing (in dots) the location of the light spots.

r-m cross-vein, just beyond second radial cell, and at tips of cells R_5, M_1, M_4, and anal cell. Vein M_1 and distal part of vein M_2 with light border. Light streak in about the middle of cell M_1 and another in cell M_2 below the terminal spot of that cell. The last mentioned streak becomes confluent with a spot in front the mediocubital fork and with the cross-vein spot and the light area at the base of anal cell and the base of wing. Outer margin of anal cell light in color. Not very distinct light area behind the radial cell. Knees clearly dark with light bands above and below. Eyes black, contiguous. Proportion of last five segments of antennal flagellum to first eight about 3:2. Third segment of palpi longer than second, well swollen, and with quite large and shallow sensory pit. Fifth longer than fourth. There are two oval spermathecae each of about 55 μ. in diameter. Base of duct sclerotized for a good distance (about 14 μ). Rudimentary spermatheca long and narrow (24 by 3 μ). Ring, of about 5 μ long, present.

MALE : Hypopygium apico-lateral processes small and almost parallel. Ninth tergite narrowed distally and without conspicuous notch in the middle. Ninth sternite little emarginate. Membrane ventral to the aedeagus not spinose. End of dististyles not enlarged. Ventral and dorsal processes of basistyle well developed. The ventral, boat hook-shaped. Base of parameres bent; stem carrying distally a knob; tip bent and strongly spinose. Terminal portion of aedeagus long and tapering.

HOLOTYPE (male), Baghdad, June 27th, 1954, in the British Museum; ALLOTYPE (female), Baghdad, June 24th, 1954, in the British Museum.

It had been collected in Baghdad between April 25th and July 17th. It was rare.

C. similis has been originally described by CARTER et AL. from the Gold Coast, in 1920. In 1938, it was reported by CAUSEY from Siam. The Iraqian form well agree with the reported characteristics of the hypopygium and the spermathecae.

These are some of the points of *C. similis* from which our material deviates : (1) eyes separate; (2) body dark brown; (3) striped and spotted mesonotal pattern, clear; (4) maculation of the wing. In addition to these, other differences appear from CAUSEY'S description of the palpi of *C. similis*. MACFIE (1943) reported *C. similis* from Egypt. He stated that the thorax in a few of the specimens was quite light brown in colour.

C. iraqensis nov. spec.

Of this species, only the male is known. It is of medium size. Mesonotal pattern present. Second radial cell included in a light spot. Hypopygium without apico-lateral processes.

MALE : Mesonotum dark brown. There seems to be some kind of pattern but because of the collapsed condition of the thorax the details of the pattern could not be made out. Metanotum dark like the mesonotum. Scutellum with a lighter color on the sides. Halteres whitish. Abdomen of a lighter color than the mesonotum. Wing almost devoid of macrotrichia. Distal half of second radial cell included in a very large light spot. Large light spot at end of cell R_5. These two light spots are separated by a dark area which is narrower than either one of the light spots. Light spot at r-m cross-vein. A very dark small spot in the region of radial cells including the basal half of second radial cell. Light spot at base of cell M_1. Light streak at top of this cell. Top of vein M_1 is dark. Light spot at top of cell M_2 and another nearly filling cell M_4. There is also a light streak in cell M_2 that runs down to join light area at the base of wing. Nearly all the anal cell light. It is not so near top and middle. Legs yellowish; knees dark with light band above and below. Eyes black.

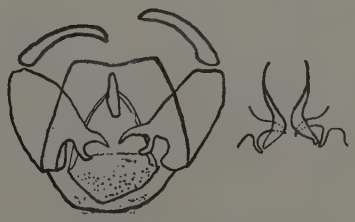

FIG. 5: Male hypopygium of *Culicoides iraqensis* nov. spec., dorsal view.

In the hypopygium (Fig. 5) there are no apico-lateral processes. Posterior border of ninth tergite notched in the middle. Ninth sternite deeply emarginate. Membrane ventral to the aedeagus spinose. Slender part of dististyle long and the free end not enlarged. Processes of basistyle together, shaped like a pincer. Parameres

have a wide base, stem tapers gradually to a fine point. Arch of aedeagus with a membrane joining the sides for a considerable distance. There is an anterior projection opposite the terminal portion.

HOLOTYPE (male), Baghdad, May 24th, 1954, in the British Museum. In Baghdad, few males were collected near the end of May and in June. It was rare.

This new species belongs to a group (the *chiopterus*-group) which is very widely distributed. Its closest relative seems to be *C. jacobsoni* Macfie which was described from Sumatra, in 1934. The hypopygium of the Sumatra specimen differs from our material in the deep cleft in the middle of the posterior margin of the ninth tergite, the presence of papillae on the terminal portion of the aedeagus, and in minor details in the shape of the parameres. MACFIE neither showed the shape of the styles and their processes, nor did he give the specific figure for the wing which he describes in a comparative way. Moreover, there might be important difference in the degree of the development of the processes of the styles. The Iraqian form is given here specific standing, although in the future it might prove to be a subspecies. To decide this, more material of both sexes for both species is required. The Iraqian form is also closely allied to the African species *C. pallidipennis* C. I. M. which was described in 1920. Differences are found in the colour and in the hypopygium. In our material the ninth tergite is not broader posteriorly. The details of the shape of the parameres are also different. In the African species, the processes of the basistyle, most probably are not well developed and the membrane not spinose ?

C. odibilis Austen

Mesonotal pattern, distinct. Among the light spots of wing, one at tip of cell R_5 and another at vein M_1. Third segment of palpi shorter than second. End of parameres tapering and pointed. Terminal portion of aedeagus short but not pointed.

FEMALE : Moderate in size and dark brown color. Mesonotum dark brown. This, together with grayish pubescence, form a very distinct pattern of the spotted-striped type. There are two sub-median stripes, each of them containing in the prescutellar depression a dark center. Two brown spots in front of the dark centers. In the brown area on the side there are two gray spots, one behind the other. Halteres whitish. Macrotrichia very dense and well distributed over wing surface. Second radial cell included in a dark spot. Light spots just beyond second radial cell, at tips of each of cells R_5, M_1, and M_2, and in cell M_4. Two light spots at tip of anal cell, which appear confluent in the male. Light spots at cross-vein and extending to the costa, on vein M_1 behind the light spot beyond the second radial cell, near base of cell M_1, in front of medio-cubital fork, and in front of that on the medial fork confluent with the spot on cross-vein. Light streak in cell M_2 above the spot in front of the medio-cubital fork. Light area near the base of anal cell. Light spot in front

of that in cell M_2 and another round spot further down in the wing. Legs dark brown, kness dark, light bands above and below. Eyes black, narrowly separated. Last five segments of antennal flagellum little longer than first eight. Third segment of palpi shorter than second, moderately swollen, and with shallow sensory pit. Last two segments subequal. There are two spermathecae, each of about 40 μ in diameter. The rudimentary spermatheca of about 12 μ long. Base of duct sclerotized for a short distance (about 4 μ).

MALE : Hypopygium apico-lateral processes well developed and divergent. End of dististyles not enlarged. Ventral and dorsal processes present. Parameres with base bent, relatively slender, and with enlarged end; stem swollen; end tapering and pointed. Aedeagus with high arch and terminal portion which is short but not pointed.

It was collected in Shaklawa in August, 1954.

This species has been originally described from Palestine (AUSTEN, 1921). Our form well agree with the description. More illustrations were given by EDWARDS et AL, 1939, with which the Iraqian material agree very well. In addition to that, HILL (1947) and also GUTSEVICH (1952) have worked and figured this species.

C. shaklawensis nov. spec.

Mesonotal pattern, distinct. Large light spot at tip of cell R_5. Small spermathecae. End of parameres tapers to a fine point. Terminal portion of aedeagus moderately long.

FEMALE : Moderate in size. Body, including the legs, dark brown. Mesonotum brown with gray pruinescence. The two colors form striped pattern. There is a heart-shaped brown area in the anterior mid-region, extending in front as a brown streak to the anterior brown border of the mesonotum. Behind the heart-shaped mark, the mesonotum is gray, except for two submedian dark centers. There is a large brown area on each side which contains two gray spots. Scutellum brown like the mesonotum. Halteres whitish. Macrotrichia well represented (even in the anal cell), except at the base of wing. Second radial cell included in a dark spot. Light spot (Fig. 6) just beyond second radial cell. A narrow dark area separates this spot from a large light spot that fills the rest of cell R_5. Other light spots in the region of cross-vein, at tip of each of cells M_1, M_2, M_4, and two at tip of anal cell. Small dark area below the spot at tip of cell M_1, and a similar area below the spot at tip of cell M_2. Rest of cell M_2 and most of cell M_1 light in color. Base of anal cell light colored with dark center. Veins M_1 and M_2 light in color between the two spots of cell M_1. Light area at the base of wing. Legs and knees dark brown. Light bands present. Eyes black, very narrowly separated. Last five segments of antennal flagellum about equal to first eight. Third segment of palpi slightly longer than second, well swollen, and with a large shallow sensory pit. Fifth slightly longer than fourth. There are two small spherical spermathecae, each of about 35 micra in diameter.

Base of duct sclerotized to a moderate distance (about 6 μ). Rudimentary spermatheca and ring present.

Male : Hypopygium (Fig. 7) apico-lateral processes well developed and divergent. Ningth tergite notched in the middle. Ninth sternite emarginate. Distis-

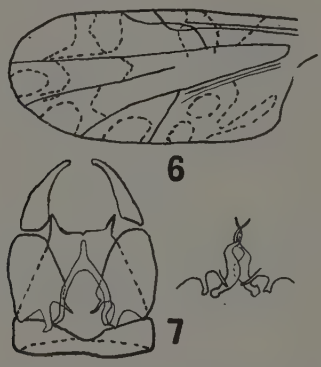

Fig. 6: Wing of *Culicoides shaklawensis* nov. spec., showing (in dots) the location of the light spots. — Fig. 7: Male hypopygium of same, ventral view.

tyles not enlarged at the free end. Ventral and dorsal processes about equally well developed. Base of parameres slender ; stem well swollen, bent distally and tapers gradually to a fine point. Aedeagus with high arch, terminal portion moderately long.

Holotype (male), Shaklawa, August 17th, 1954, in the British Museum.

This species bears some resemblance to *C. clarkei* C.I.M. which was described from the Gold Coast. There are, however, differences in the thoracic coloration, the extensiveness of the wing spots, and in the details of the hypopygium.

C. pictipennis (Staeger)

Superficially, this species is closely similar to *C. odibilis*. Mesonotal pattern of the indistinct type. Among the light spots of the wing, one at tip of cell R_5 but no spot on vein M_1. End of parameres tapers to a fine point. Terminal portion of aedeagus wide at base.

Female : Of moderate size and dark colored body. Mesonotum brown with grayish pubescence and numerous, relatively long hairs. The pattern is composed of two sub-median gray stripes which contain dark centers in the pre-scutellar depression and two gray spots on each side one behind the other. However, the pattern in general is not distinct because of the extensiveness of the gray areas. In this respect, this species differs from *C. odibilis*. Scutellum and metanotum like

mesonotum in color. Halteres with gray stem and whitish tip. They appear sometimes reddish. Macrotrichia dense and well distributed except near base. Wings dark and the spots show well. Second radial cell included in a dark spot. Light spots (Fig. 8) at cross-vein, just beyond second radial cell, at tips of cells R_5, M_1, M_2, M_4, anal cell, and near base of cell M_1. Light spot in cell M_2, behind the last mentioned spot, extends to the base of wing in the form of a streak confluent with the cross-

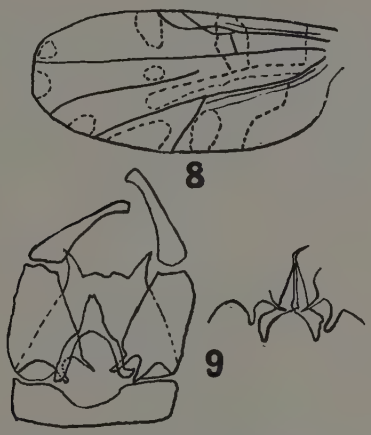

FIG. 8: Wing of *Culicoides pictipennis* (Staeger) showing (in dots) the location of the light spots. — FIG. 9: Male hypopygium of same, ventral view.

vein light spot. Light area near base of anal cell and base of wing. Knees dark. Legs of the banded type. Eyes black, very narrowly separated. Last five segments of antennal flagellum of about the same length as first eight. Third segment of palpi about twice the length of second, well swollen and with shallow sensory pit. Fifth little longer than fourth. There are two, oval spermathecae, each of about 40 μ in diameter. Base of duct sclerotized for about 5 μ. Rudimentary spermatheca of about 15 μ long. Ring of about 5 μ.

MALE : Hypopygium (Fig. 9) apico-lateral processes well developed and divergent. Posterior border of tergite notched. Ninght sternite emarginate. Membrane ventral to the aedeagus not spinose. End of dististyles not enlarged. Ventral processes of basistyles less strongly developed than dorsal processes. Parameres with expanded foot-shaped base, with heel near base; stem little swollen and tapers gradually; they are bent shortly before the fine end. Arch of aedeagus high and rounded. Terminal portion, wide basally and narrows suddenly near end.

It had been collected in Shaklawa in August, 1954.

In the Iraqian material, the spots at the distal end of the cells are smaller than what was shown in the figure given by EDWARDS et AL (1939). Such difference was

reported by him. The figures given by EDWARDS for the hypopygium are somewhat different but the description in general applies to the Iraqian specimens. The same species was reported from Palestine (*C. guttularis*, AUSTEN 1921).

C. longipennis nov. spec.

FEMALE : Of small size and brown color. Mesonotum brown with grayish pubescence which forms a distinct pattern. There are two short submedian gray stripes which appear as spots on the humeral pits. There is a small gray spot behind each of the preceding stripes. Behind these two spots, in the pre-scutellar depression, there are two wide stripes each with a dark center. There are three round gray spots on each side. In addition, there is gray coloration on the margin. Scutellum like mesonotum. Halteres whitish. Macrotrichia rare in the lower part of wing. Second radial cell is included in a dark spot. Light spots (Fig. 10) just beyond second

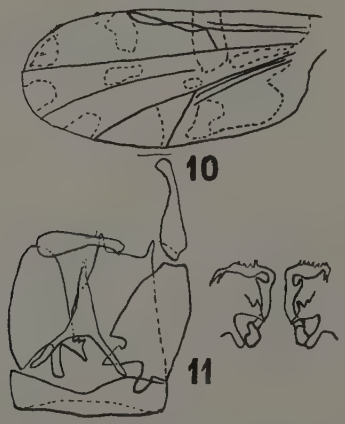

FIG. 10: Wing of *Culicoides longipennis* nov. spec., showing (in dots) the location of the light spots. — FIG. 11: Male hypopygium of same, ventral view.

radial cell, at tips of cells R_5, M_1, M_2, M_4, and near middle of cell M_1. Cross-vein light spot touches a streak in front of a spot anterior to the medio-cubital fork. Large light spot fills the tip of anal cell. Light area at base of wing and base of anal cell. Outer margin of anal cell is also light. Knees dark with bands above and below. Eyes black, almost touching. Last five segments of antennal flagellum little longer than first eight. Third segment of palpi about twice the length of second, well swollen and with shallow pit. Fifth little longer than fourth.

There are two oval spermathecae, each of about 50 μ in diameter. Base of duct sclerotized for a long distance (about 18 μ). Long, slender rudiment (about 28 by 3 μ) and a ring present.

MALE : Hypopygium (Fig. 11) apico-lateral processes almost parallel. End of tergite between them narrow and not notched. Ninth sternite emarginate. Membrane not spinose. The ventral processes shaped like boat hook. In the parameres, the stem of about the same width throughout and carries a knob near top; the end bent and strongly spinose; the base knobbed and the bent part short. Terminal portion of aedeagus long and decreasing gradually in width; end with irregular serration.

HOLOTYPE (male), Shaklawa August, 11th, 1954, in the British Museum; ALLOTYPE (female), Shaklawa, August 20th, 1954, in the British Museum.

C. longipennis has general similarity to *C. similis baghdadensis*.

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BIOLOGICAL STUDIES ON THE OLIVE SCALE, *PARLATORIA OLEAE* (COLVÉE)

[*Hemiptera-Homoptera* : *Coccoidea-Diaspididae*]

(with 5 Graphs and 6 Text-Figures)

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INTRODUCTION

This work was done in the Department of Entomology, University of Maryland (U.S.A.). Gratitude is due to Professor Dr. E. N. CORY, the previous Head of this Department and State Entomologist, for his encouragement during the course of study; as well as to Professor H.S. MCCONNELL, of the same Department, for his continuous help.

In 1927, *Parlatoria oleae* (Colvée) was observed for the first time in Baltimore (Maryland) on a hedge of California privet (*Ligustrum ovalifolium*). An unfruitful effort was carried on to ascertain its source. However, MCCONNELL stated that from the information available about its distribution and host plants, the Mediterranian region seems to be the original home of this insect. MACKIE reported that it may have been introduced on live cuttings from Greece or Italy. In Arizona, NICHOL and WEHRLE mentioned that two aged almond trees were found about 1925 to be the nuclei of the infestation. Meanwhile, the latter authors believe that the insect was probably introduced into that area much earlier, i.e. in 1891.

In 1931, the scales became noticable on the olive trees of California, and have since become increasingly injurious. Later on, in 1951, they were found on plum (*Prunus cherry*) in Maryland.

This scale was originally named as *Diaspis oleae* Colvée, then *Parlatoria affinis* Newstead, *Parlatoria calianthina* Berlese and Leonardi, and even *Euparlatoria calianthina* (Berl. qnd Leon.). Therefore, great care should be taken when examining literature about this pest, especially because it has been frequently mistaken for the ivy scale, *Aspidiotus hederae* Vallot, or for the San José scale, *Quadraspidiotus*

perniciosus (Comst.). As far as the common name is concerned, the American Association of Economic Entomologists approved calling it "the olive scale" according to its principal host in California. For the same reason, the insect might have other names in the different countries, such as "the plum scale" in Egypt.

Economically, this pest is greatly important. MACKIE and others reported in 1939 that 159 plants of nearly 100 genera were attacked by *P. oleae*, and EBLING stated in 1949 that the scale can develop on over 200 host plants. Many of its hosts are crops of major importance, such as pears, plums, and olives. They become seriously affected by the infestation which covers the small branches as well as the leaves and the fruits. The attacked fruits are pitted where the infestation is light, or rinkled where it is heavier. In short, they become malformed, frequently discoloured and completely ruined for canning purposes.

From the stand point of control, EBLING stated in 1949 that the olive scale is very resistant to the existing control measures. This statement is comprehensible due to the accumulative nature of the infestation. The progeny frequently develops beneath the old scales, which act as a schelter and consequently as an insecticide-proof. This phenomenon had drawn attention in the States to the possible use of biological control by introducing some successful enemies for this pest from other countries. Few years ago, Dr. A.M. BOYCE of the University of California visited Egypt for this purpose. It might be worth mentioning here that during the present work, certain mites were found beneath the scale of *P. oleae* from August to October. Dr. E. W. BAKER, of the U.S. Department of Agriculture, kindly identified them as *Cheletomimus berlesei* (Oudns.) and *Cheyletia* spec., family *Cheyletidae*. Both mites are known to be predators.

This being the case of *P. oleae* in the States, it had been thought that the study of its biology in Maryland might help in solving the problem.

BIOLOGY

Technique

In early spring of 1951, a sufficient number of cuttings of the deciduous privet (*Ligustrum ovalifolium* = *L. californum*) and of seedlings of the evergreen one (*L. lucidum* or *japonicum* as identified by some authers) were planted in three-inch pots to breed the scales in the laboratory for close observation. In April, some infested privet plants with soil around the roots were brought from Baltimore and planted outside in order to watch the insect's activity under normal conditions.

Breeding started by placing some of the newly hatched larvae on the potted plants at different dates all over the period of activity. Mostly about the beginning of each month, few breeding pots were put in contact with the infested stock outside for two days. As the crawlers from the mother scales on the stock may crawl to the breeding plants any time, the intermediate day is taken for the date of hatching plus

or minus one day. By the aid of a binocular, the positions of the insects, which are to be kept under observation, are determined, and a diagram for each breeding plant is drawn showing these positions. Three or four insects are usually bred on each plant and given a serial number.

Before the bred females started to give crawlers, a certain precaution had to be taken to prevent the loss of the crawlers produced. A disc of paper was fixed around the base of the stem and sealed to it by scotch tape. Vaseline was applied around the sealing and on the paper disc to trap the crawlers as illustrated in Figure 1. Edges of this disc are raised in two opposite points to allow watering, aeration, and to prevent fungus growth.

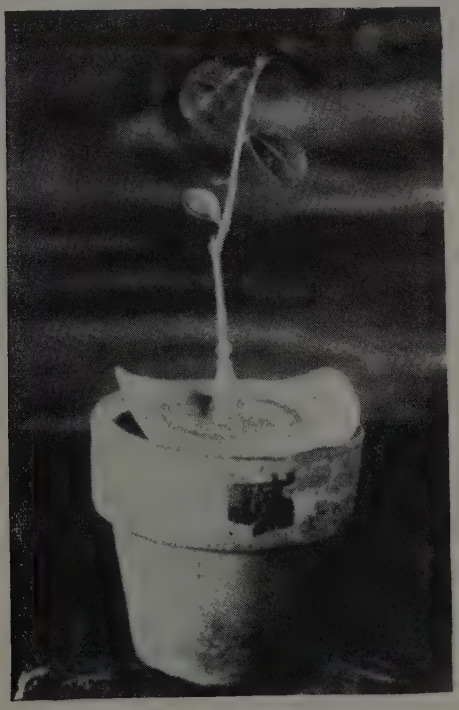


FIG. 1: A breeding pot.

The evergreen privet showed considerable immunity all over the period of breeding, as crawlers never settled on its seedlings. Besides this, only two intermediate females and a scale of emerged male were found on the evergreen shrub outside during the whole season, in spite of the fact that some of the infested stock was plated in contact with this shrub.

Some insects were bred on squash fruits. The newly hatched larvae were transferred by fixing a piece of an infested twig to the fruit by a rubber band. The settled insects were numbered with Indian ink on the fruit. The adult males emerged successfully on squash, but there were some abnormality in the scales of adult females. The waxy covering was so thin that the female body appeared as a dark figure through its scale (Fig. 2).

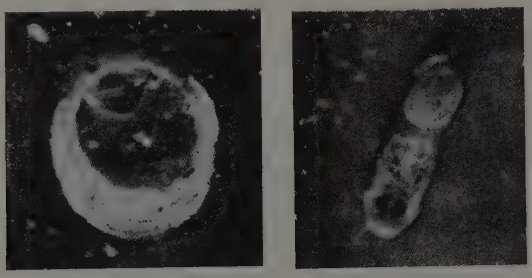


FIG 2: A female with body showing through scale (left); a male scale (right). — On squash fruit, ×15.

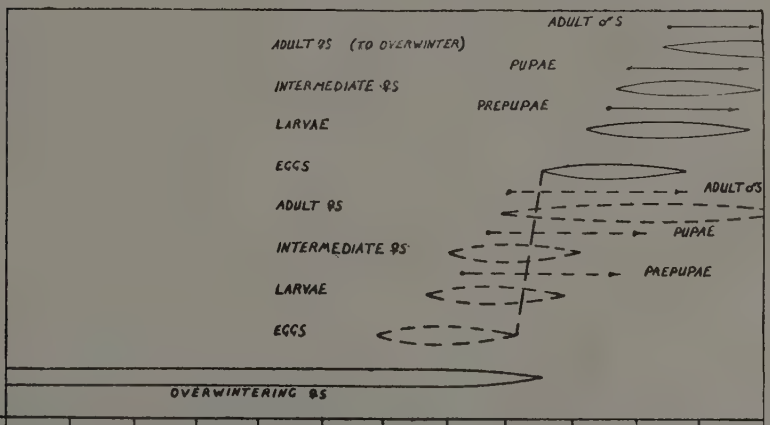
The total number of insects taken as nucleus for breeding to study the life history was 81 larvae. Out of this number, 8 died before the first moult and the data for the remaining 73 were arranged in separate Tables for males and females. From these Tables, other Tables are arranged to represent the life duration of certain stages, taking into account to group the bred insects isothermally, beginning with the highest temperature downwards. To make these Tables more comprehensible, Graphs are drawn relating the duration to the temperature. For lack of space, Tables are here ommited and the discussion is supported by the Graphs only.

Besides the laboratory work, the infested stock outside had to be examined periodically at intervals of about two weeks. The number of insects on the stock was quite enough to permit more study of certain durations. The scales of a considerable number of insects taken at random were removed in every test in order to determine the percentage of each existing instar and to watch egg laying from the beginning till the end, etc.. Microscopical preparations were made in the course of more precise determination of instars. The examination of the stock proved to be of great benefit in studying the seasonal cycle of the olive scale under natural conditions, and in giving a fair idea about certain durations such as the preoviposition, oviposition and incubation periods which could have not been easily studied with accuracy under the limited laboratory conditions. Graph I represents the results obtained from these periodical tests. The length of each spindle-shaped area in the Graph represents the stage concerned, while the breadth represents the variation in number of each instar through the duration and not the number itself. The male stages are represented by arrows.

The egg

Incubation period : It is well known that the adult female lays its eggs beneath the scale and if this scale is removed, egg laying may be interrupted. This condition renders it difficult to determine the date of laying any particular egg. On the other hand, eggs could not be kept under observation until hatching, under natural conditions out of the scale. Therefore the date of hatching for any particular egg is hard to determine. By missing both the date of laying and the date of hatching of a particular egg, it would be satisfactory to have an idea about the incubation period from Graph I.

GRAPH I



MONTH	NOV. 1950	DEC.	JAN. 1951	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEP.	OCT
TEMPT. °F	—	—	—	—	—	—	66.7	73.5	78.8	78.5	74.7	65.7

FALL BROOD SPRING BROOD

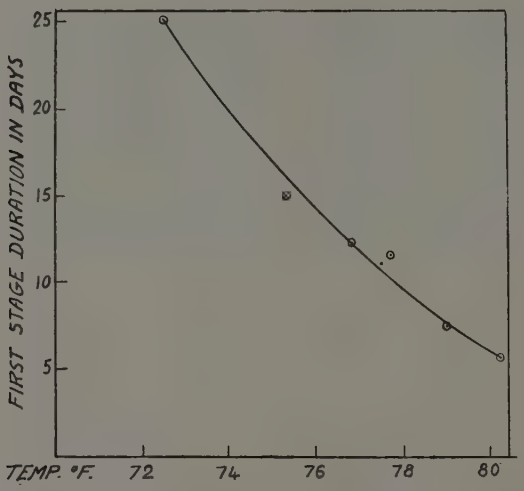
Out of this Graph, it is obvious that the incubation period for the eggs of the spring brood varies from about 26 days in May in an average temperature of about 66.7 °F to about 22 days in July in an average temperature of about 78.8 °F. For the fall brood, this period between about 22 days in July to about a month in October.

Percentage of hatching : During the course of study, the new hatch that came out of five scales was counted and found to be 270 crawlers. At the end of the season, the five scales were removed and beneath them were found 5 dead eggs, 51 dead crawlers, and 1 intermediate female. This means that out of 327 eggs, only 5 eggs failed to hatch, giving a hatching percentage of 98.5%. In other words, the natural mortality during the egg stage is very low, about 1.5%.

First larval stage

Duration : It is known that this duration represents the time elapsing between hatching and moulting for the first time. The date of hatching is here considered to be the date on which the larvae escaped from beneath the scale, while the date of moulting is that on which the first exuvial integument started to form a covering scale.

GRAPH II



The duration of this stage is represented by Graph II, in which the curve joining the encircled points gives the relation between the average temperature and the average duration. This graph shows that the first larval stage lasts from about 5.7 days at about 80.2 °F to 25 days at about 72.5 °F.

Natural death : The discussion about the percentage of hatching indicates that out of 323 newly hatched larvae, 51 died beneath the mother scale. This means that the natural mortality in the first instar larvae beneath the scale is about 15.9%. After having been released from the mother scale, 8 first instar larvae died out of the 81 bred insects. This means that the natural mortality in the first instar larvae settled of the host plant is about 9.9%. These figures lead to the final calculated result that the natural moratlity during the whole first larval stage is about 24.2%.

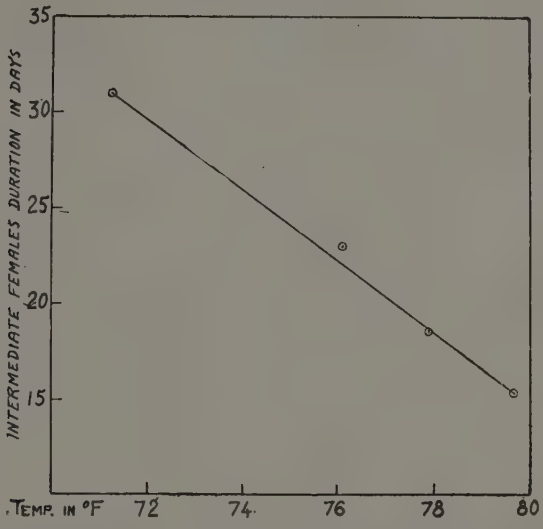
Intermediate female stage

The insect stays in the intermediate stage until its second moult, which is recognised as the second exuvial integument enters in the construction of the scale.

Duration : The duration of this stage is represented by Graph III, in which the line joining the encircled points demonstrated the relation between the average

temperature and the average duration. It is obvious that the intermediate female stage lasts from about 15 days at an average temperature of 80 °F to about 31 days

GRAPH III



at an average temperature of 71 °F. Meanwhile, the straitness of the Graph indicates that the rate of increase in the duration is proportional to the rate of decrease in temperature.

Adult female stage

Pre-oviposition period : Facing the same problem explained in the discussion of the incubation period, Graph I is also used here to give an idea about the pre-oviposition period. The duration of this period appears to be very long for the over-wintering females since it includes the hibernating period. It lasts for about eight months from September to April. The same period for the females of the spring brood is only about 20 days in July when the tempeature averages about 78.8 °F.

Oviposition period : Due to the fact that eggs are laid beneath the scale, and the removal of the scale might interrupt egg laying, Graph I is here applied to give a fairly good idea about the oviposition period. For the fall brood, i.e. the overwintering females, this period is about 70 days mostly in May at average temperature of 66.7 °F and June at average temperature of 73.5 °F. For the spring brood, the period is the same, i.e. 70 days, but happens in July and August. It should be noticed that figures are not for any particular female or any group of females, but they represent the oviposition period for all the females in each brood. In other words, they indicate the time in which eggs of *P. oleae* are found in the vicinity of the present work.

NICHOL and WEHRLE mentioned that eggs of *P. oleae* in Arizona may be found every month except December and January.

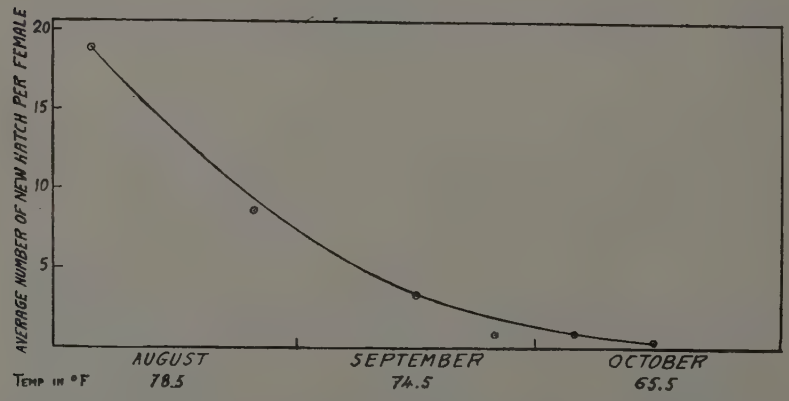
Number of eggs laid : From the previous discussion about the percentage of hatching, it appears that the number of eggs laid by five ovipositing females from the spring brood is 327. This number makes an average of about 65 eggs per female.

Having no isolated females of the fall (overwintering) brood, the number of eggs per female of this brood was not reached. However, MCCONNELL reported that the overwintering females lay an average of about 60 eggs each.

In Arizona, NICHOL and WEHRLE mentioned that the average number of eggs laid per female varies from 50 to 100 eggs.

Crawlers production period : This period might be called "the hatching period". The crawlers of the spring brood started to come out about the end of May and ended late in summer. The exact date of its end cannot be given because of having no isolated females of the overwintering insects and because the hatching period of this brood may overlap that of the fall brood. However, Graph I shows that the crawlers production for the spring brood ends about the second half of July, i.e. lasting for about two months in average temperature from 73.5 to 78.8 °F. The crawlers of the fall brood started to come out in the laboratory, as well as in the open, about the beginning of August and ended shortly before the end of October, lasting for about three months in daily average temperature varying from 65.7 to 78.5 °F.

GRAPH IV



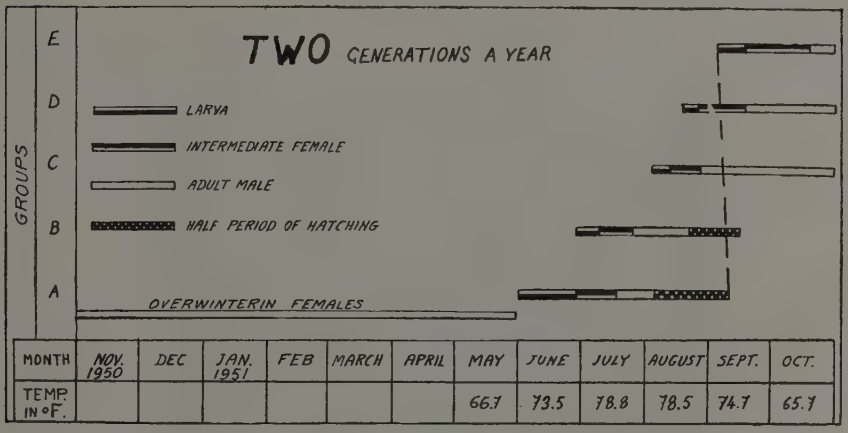
Graph IV represents the average numbers of crawlers produced per female all over the crawlers production period. The curve shows that the highest number of crawlers is produced at the beginning of this period.

According to NICHOL and WEHRLE, the hatching period of this insect in Arizona starts earlier than in Maryland by about six weeks in the spring brood and two weeks in the fall brood.

Number of generations per year

Graph V represents five groups of insects indicated by letters A to E. These are groups of insects experimented under laboratory conditions, and the members of each group had started as new hatch about the beginning of each month. For each group, the graph represents the averages of the larval stage, the intermediate female stage, the preoviposition and incubation periods, and half the crawlers produc-

GRAPH V



tion period. Only half the crawlers production period is considered here in order to take the crawler that came out in the middle of this period as a representative. The Graph also gives the average temperature for each month of breeding. It is obvious from the graph that there are *two generations* a year. The longer life cycles were those starting about the beginning of June and the beginning of July. They were initiated from the early eggs of the overwintering females.

The male

Duration of life : The male of *P. oleae* moults four times. It has five stages, the first and second larval, the prepupal, the pupal, and the adult stages. The first larval stage ends when the first exuvial integument enters in the construction of the scale. The other stages can be recognised by examining the insect itself. Since this examination requires the removal of the scale, and consequently interrupts the insect's life, it has been applied in the outside stock only, where the number of insects allows such loss.

The duration of the first larval stage is represented by Graph II because there is no apparent difference between males and females of this instar. The durations of the other stages are represented by arrows in Graph I. This Graph gives the impression

that the adult males occur in two broods, a spring brood lasting from July to September, and a fall brood starting about the second half of September and ending in October. In other words, males of the olive scale could be found in Maryland at any time between July and October.

In Arizona, NICHOL and WEHRLE reported that males of the olive scale had been taken in all months except from November to February. This means that the occurance of the males there starts on March, i.e. four months earlier than in Maryland. However, these authors stated that the two large flights of males had been seen in July and October.

During emergence, the adult male creeps backward out of the scale pushing out the third and fourth exuviae as appearing in Figure 3. This process takes a short

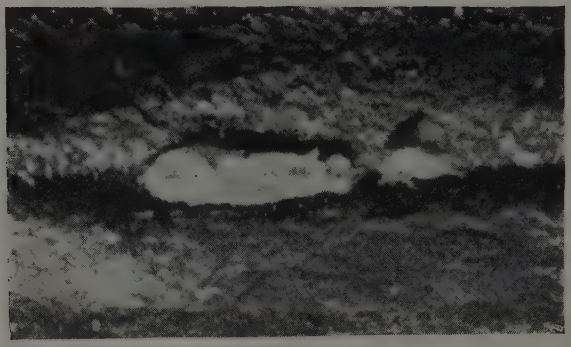


FIG. 3: A male scale with the adult emerging and pushing the exuviae outside, X 15.

time, leaving no sign of emergence in the scale. A matter that renders it difficult to determine the exact date of emergence, and consequently the duration of the male's life. Fortunately however, the emergence date has been determined in three cases. The first case was an insect that hatched on July 30 and accidentally observed during emergence on August 28, i.e. completing its life from hatching to emergence in 29 days at an average temperature of 78.7 °F. The other two cases were crawlers on squash on August 18 and moulted for the first time on August 26. They were observed soon after emergence on September 24. In other words they had completed their life cycle, from crawler to adutlt, in about 37 days in average temperature 76.3; and they lasted in the second larval, pre-pupal, and pupal stages together for about 29 days in average temperature 75.5 °F.

Natural death : Out of 49 males, 42 emerged and 7 died after the first moult. These figures show that the natural mortality in the prepupal and pupal stages grouped together is about 14.3%.

Sex ratio : Out of 73 bred insects, only 24 were females and the remaining 49 insects were males. This means that the sex ratio is about 2 males : 1 female.

WAMPLER observed during his work on *P. oleae* in California that extensive damage is caused by males. He stated : "The sex ratio is markedly in favor of the males and mortality is quite low. In the case of this coccid, the males are at least as distinctive as the females and may well be the more important sex in terms of damage to live fruits".

Fertilisation : Fertilisation is essential for *P. oleae* to reproduce. In 1947, STAFFORD reported that parthenogenesis does not occur in the olive scale, and

FIG. 4: A normal female scale on privet twig, x 15.

FIG. 5: Abnormal scale of an unfertilised female with hind part of pygidium protruding, x 15.

accordingly thought of killing the males as a possible easy way to control this pest. He also mentioned that the scale of an unfertilised female usually did not cease after reaching the normal shape and size. This condition occured in certain cases

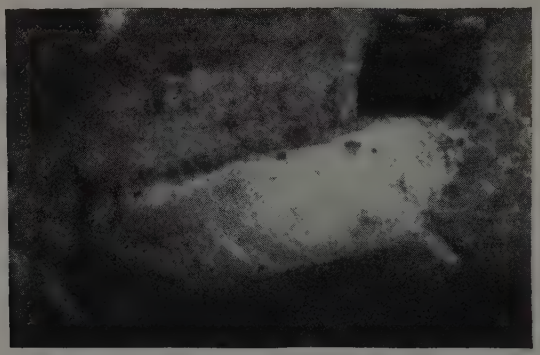


Fig. 6: Abnormal scale of an unfertilised female with all the insect outside the scale, x 10.

during the present work. Figure 4 shows the normal female scale, while Figure 5 shows an odd curved scale of an unfertilised female with the posterior portion of the body protruding from beneath the scale. Ultimately, the female would work its body completely outside of the scale, probably attracting the male's attention, as appears in Figure 6.

CONCLUSION

From the previous discussion one may conclude that :

1. — The olive scale (*Parlatoria oleae* Colvée) has gained credit in U.S.A. as a polyphagous, quickly spreading pest, attacking several economic crops such as olives, pears, pulmus, etc.

2. — Parthenogenesis does not occur in this insect.

3. — The number of males to the number of females is 2:1.

4. — Males could be found in Maryland any time between July and October.

5. — The insects overwinter from November to April as fertilised females on the host plant.

6. — A female produces an average of 65 eggs.

7. — There are two broods for this insect in Maryland, a spring brood from the eggs laid by the fertile overwintering females, starting the beginning of May; and a fall brood from eggs laid by the fertile females of the spring brood, starting about the middle of July.

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EGG-LAYING AND HATCHING HABITS OF MAGICICADA SEPTENDECIM (LINNÉ)

[*Hemiptera-Homoptera* : *Cicadidae*]

(with 3 Text-Figures, 1 Graph, and 2 Tables)

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INTRODUCTION

The insect under consideration, as obvious from its specific name, completes its life cycle in seventeen years, and therefore aquired the common name of the 17-year cicada, or sometimes the 17-year locust. It was about May 10, 1953, when this insect made its latest appearance in Maryland, U.S.A.; and the Marylanders became seriously worried about its buzzing. The opportunity was then available to carry on certain studies about this phenomenon which would not be expected, in that area, before 1970, the year the periodical insect is due to re-emerge. Gratitude is here submitted to Dr. CORY, the previous Head of the Department of Entomology, University of Maryland, and State Entomologist, for suggesting the work and for his encouragement throughout the course of study.

Egg-laying

About the middle of May, the adult female cicadas started to lay their eggs. In June, these eggs were found beneath the bark of twigs of different kinds of trees. They are very delicate, pearly white, about one-twelfth of as inch long, slightly curved, and deposited in the two arms of an inverted Y-shaped gallery in a neat arrangement of two rows of eggs in each arm. The upper part of the gallery connects the two arms with the outside opening. The formation of these galleries causes the protrusion of bundles of splinters. Figure 1 shows an infested Azalea twig with a series of such bundles, Figure 2 shows the shape of a gallery with eggs removed, and Figure 3 shows egg in situ.

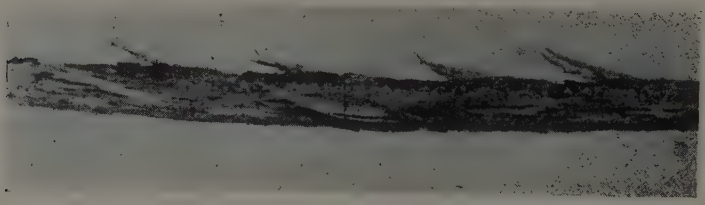


FIG. 1 : An infested *Azalea* twig showing the series of protruding splinter bundles (about norival size).

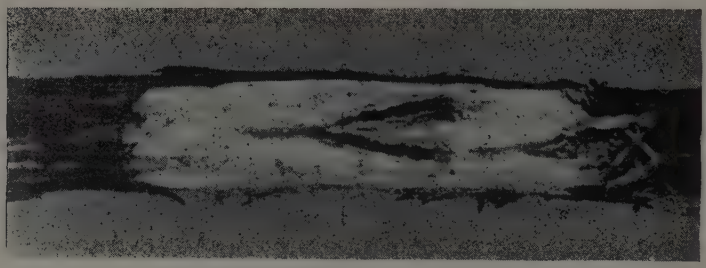


Fig. 2 : A gallery with the bark and eggs removed to show the inverted Y-shape of the gallery (enlarged).

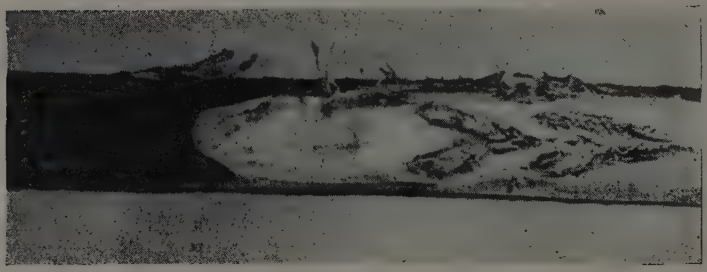


FIG. 3 : Two galleries with bark removed, but eggs in situ (enlarged).

The number of eggs per gallery varies from 15 to 42 with an average of about 30 eggs.

Hatching

Technique : In order to watch the development of the embryo, microscopic preparations were made at short intervals. For interested workers, permanent mounts of the embryo at different ages, and of nymphs after shedding the embryonic mem-

brane, may be available at the Department of Entomology, University of Maryland, where the work was done. The best results were obtained by fixing the eggs in Allen's B 15 at about 80 °F for 2 hours, clearing in cedar oil overnight and staining with carmine borax. However, some of the preparations were treated with caustic potash and either stained with basic fusion or left without staining. Meanwhile, several vials, each containing eggs at a certain age and a vial containing nymphs after shedding the embryonic membrane, are also available in the place of the study. The material in these vials was fixed in Allen's B 15 for 2 hours, then transferred through alcohols up to 70% in which it has been preserved. Being kept this way, the preserved material can be used later on for sectioning or microscopic preparation by workers wanting such stuff.

To determine the exact date of hatching in the area, a cage was fixed in the open with a screen top holding the egg-laden twigs and with a muslin cloth beneath to receive the new hatch. Inside the laboratory, other arrangements were fixed to watch hatching. These arrangements included several stainless steel pans containing various host twigs, and an azalea infested branch kept in water with a receptacle for catching the nymphs as they fall.

The rate of hatching was studied in azalea, chestnut, hemlock, holly, and oak. The eggs in infested fresh twigs were examined at short intervals. Counts were made for hatched and unhatched eggs; then the percentage of hatching was calculated. These counts and percentages are listed in Table I, while the percentage of hatching is represented graphically.

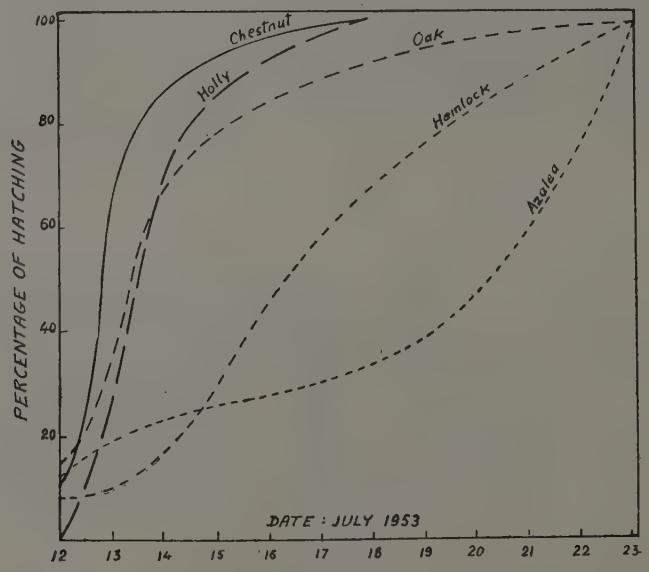
TABLE I

Host plant	Egg counts	Date : July, 1953						
		12	13	14	15	18	23	27
Azalea	Unhatched	96	100	84	111	60	0	0
	Hatched	12	92	0	0	0	120	100
	Hatching %	11	48	0	0	0	100	100
Chesnut	Unhatched	163	62	0	50	0	0	0
	Hatched	19	117	180	225	116	120	208
	Hatching %	10	65	100	82	100	100	100
Hemlock	Unhatched	93	—	108	164	32	0	0
	Hatched	8	—	24	0	72	172	118
	Hatching %	8	—	18	0	69	100	100
Holly	Unhatched	112	—	22	60	0	0	0
	Hatched	0	—	108	112	118	118	128
	Hatching %	0	—	83	65	100	100	100
Oak	Unhatched	224	48	64	24	56	0	0
	Hatched	35	16	114	156	36	136	206
	Hatching %	14	16	69	87	39	100	100

Date ot hatching : July 12th was found to be the exact date of hatching in College Park, Maryland, during the 17-year cicada outbreak of 1953. On July 4th, the embryo began to show its dark brownish eye spots through the chorion. About one day before hatching, the brownish claws and setae of the embryo's legs showed up through the chorion, and this phenomenon may be considered as the final signal before hatching.

Observations on hatching : The new hatch emerges from a split at the anterior end of the egg. Since the limbs of the new hatch are still at that time ensheathed in embryonic membrane, it is possible that the chorion is split under pressure created by a series of contractions directing waves of the body fluid anteriorly.

Apparently all the eggs in a mass hatch about the same time, but the nymph near the opening of the gallery emerges first, followed by the others in sequence. It takes the new hatch about 10-30 minutes to quit the egg shell.



The newly hatched nymph sheds the embryonic membrane usually at the outside opening of the gallery and lets itself fall to the soil. Sometimes, it wanders for a while before falling to the ground. However, the shedding of the embryonic membrane is sometimes not accomplished util the new hatch has already fallen on the ground. Occasionally, the new hatch leaves the embryonic membrane at the split of the egg shell. The shedding of the embryonic membrane normally takes about 2 minutes.

During these observations it was evident that the eggs in dry twigs usually become desiccate and fail to hatch.

Rate of hatching : The Graph shows that hatching is faster in chestnut, holly, and oak than in hemlock and azalea. Complete hatching occured in both chestnut and holly about five days earlier than in other hosts. The curves representing the rates of hatching in chestnut, holly, and oak appear in a similar pattern. They are steeper at the beginning, i.e. the rate of hatching in these hosts is faster until about 80% of the eggs hatch; then it slows down gradually towards complete hatching. In hemlock, the rate of hatching shows less variation throughout the hatching period. In azalea, the curve takes an obviously different shape by being steeper at its second half. This condition may be due to the chance in sampling, as the egg samples examined on July 14, 15 and 18 were all unhatched. These samples prevented the curve from rizsing, at this part of the hatching period.

Host overgrowth : The overgrowth of the infested twigs of chestnut, hemlock, and holly frequently blocks in the new hatch about the end of the hatching period. In such cases, many of the new hatch were found dead inside the galleries. About the end of the hatching period, i.e. on July 23rd, counts were made of egg shells from which the nymphs had emerged and successfully escaped from the galleries, and of nymphs which had failed to escape. These counts, in different hosts, are listed in Table II. The Table shows that the growth in oak and azalea is not rapid enough to prevent the escape of the nymphs from the galleries.

TABLE II

Host plant	Egg shells	Dead nymphs
Azalea	120	0
Chestnut	96	24
Hemlock	104	68
Holly	0	118
Oak	136	0

SUMMARY

The main points discussed in this paper may be summarised as follows :

1. — In 1953, the 17-year cicada, or the 17-year locust, *Magicicada septendecim* (Linné) made its appearance in Maryland, U.S.A.

2. — The adults emerged from the soil about May 10 and began egg-laying about five days later.

3. — Generally, egg-hatching started on July 12th and ended about July 23th, 1953.

4. — The rate of hatching was faster in chestnut, holly, and oak than in either hemlock or azalea. Complete hatching occured in chestnut and in holly about five days earlier than in the other hosts.

5. The infestation usually caused a certain amount of overgrowth in the tissues of the host at the site of egg-laying. In the cases of chestnut, hemlock, and holly, such overgrowth was rapid enough to block in the new hatch about the end of the hatching period.

6. — A stock of eggs at different ages, and nymphs after shedding the embryonic membrane, may be available at the University of Maryland for further study by interested workers.

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THE ASTEROLECANIINAE OF EGYPT

[*Hemiptera-Homoptera* : *Coccoidea-Coccidae*]

(with 4 Text-Figures)

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On surveying the subfamily *Asterolecaniinae* in Egypt, the writer found that it only comprises three genera with four species, namely *Lecaniodiaspis* Targ. (*L. africana* Newst.), *Asterolecanium* Targ. (*A. pustulans* Ckll. and *A. bambusae* Boisd.), and *Pollinia* Targ. (*P. pollini* Costa). The description of these species is given below, together with the list of their respective host plants that could be recorded in this Country.

The situation of this sub-family is clarified in the following short paragraphs, as far as the literature available permitted.

In 1869, TARGIONI TOZZETTI proposed the tribe *Lecanodiaspites* (later called *Lecanodiaspidites*) to be placed between his groups named *Lecanites* and *Diaspites*. COMSTOCK, when dealing with the family *Coccidae* in 1981, did not recognise this proposed tribe.

Between 1879 and 1897, MASKELL, on working out the coccids of New Zealand, divided the family Coccidae into four groups, one of which was *Lecanidinae*. Among the sub-divisions of this group, *Lecanodiaspidae* was proposed to represent the tribe proposed in 1869 by TARGIONI TOZZETTI.

In 1896, COCKERELL placed this group in a sub-family *Asterolecaniinae*. This system was more or less adopted by BERLESE and LEONARDI in 1898, by Mrs. FERNALD in her catalogue of 1903, and by GREEN in 1909.

According to the most recent concept of Coccid classification this group is considered as belonging to the family *Asterlecaniidae*, of the super-family *Coccoidea*. Miss RUSSELL (1941) grouped certain genera of this family in the sub-family *Asterolecaniinae*.

With regard to the genus *Lecaniodiaspis* Targ., it may be briefly mentioned that this genus was first proposed by TARGIONI TOZZETTI on creating his tribe *Lecaniodiaspidites*. It is listed in FERNALD catalogue under the sub-family *Dactylopiinae*. However, it is one of the genera of the old *Dactylopiinae* which represent a section currently designated as the sub-family *Asterolecaniinae*, and recently raised to *Asterolecaniidae* as indicated above. More specifically, this genus belongs to the sub-family *Asterol- ecaniinae* of Russell.

A KEY TO THE ADULT FEMALES

1 (2) Abdomen of adult female wit dorsal sieve-like (cerebriform) plates. Antennae well developed. Legs atrophied ..... **Lecaniodiaspis africana Newst.**

2 (1) Abdomen without such plates. Antennae tubercular. Legs absent.

3 (4) Margin of the body of female with 8-shaped pores, in a complete row. .... **Asterolecanium Targ.**

a (*b*) Capsule of female sub-circular. 8-shaped pores accompanied by a row of quinquelocular pores and another row of minute disc pores..... ..... **Asterolecanium pustulans Ckll.**

b (*a*) Capsule of female elliptic. 8-shaped pores accompanied only by a row of quinquelocular pores but no disc pores. .... **Asterolecanium bambusae Boisd.**

4 (3) Margin of the the adult female without such pores. A dorsal tube on either side of anal area ..... **Pollinia pollini Costa**

DESCRIPTION OF THE SPECIES

Lecaniodiaspis africana Newst.

Antonina africana Newst., *Quart. Journ. Liverpool Univ.*, I (2), pp. 69, 72 (1906).

TEST OF ADULT FEMALE waxy in appearance, short ovate or sub-circular and highly convex, 2.7-5 mms. long, colour yellowish brown or straw like, changing to grey on dead insects. On the posterior half is a median dorsal ridge with several lateral ridges on either side. In old specimens the median and lateral ridges break into minute tubercles.

ADULT FEMALE (Fig. 1) sub-circular, 2.5-4.8 mms. long and 2.35-4.10 mms. wide. Antennae about 250 μ long, normally 7-segmented. Antennal formula 4, 2, 3, 1, 7 (5, 6). The fourth segment has a deep partial segmentation which may be complete and divides it into two segments, thus making the number of antennal segments 8. This may even happen on one side of the insect causing asymmetry. Legs present but much atrophied, metathoracic leg 180μ long ranging from 140-210 μ. Spiracles normal, each with a cluster of 5-7 multi-locular stigmatic pores, but not

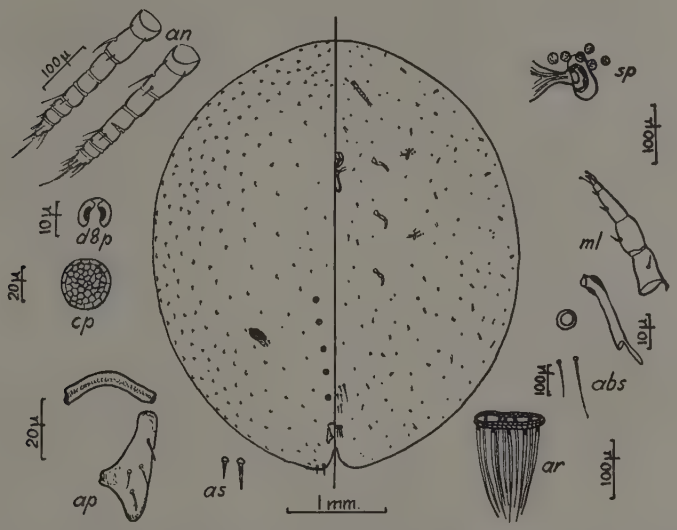

FIG. 1 : *Lecaniodiaspis africana* Newst. (*abs*, abdominal setae; *an*, antenna; *ap*, apical plates *ar*, anal ring; *as*, apical setae; *cp*, cerebriform plates; *d8p*, dorsal 8-shaped pores; *ml*, metathoracic leg; *sp*, spiracle).

extending to the margin, no stigmatic depressions on the margin. Anal ring cellular, 100 µ wide, with 10 anal setae, about 120 µ long. Anal plates, a pair of more or less triangular plates about 130 µ long and 80 µ wide, with their apices directed inwards. The anterior inner margin is slightly longer than the posterior. There are four stout, pointed dorsal setae on each plate, one near the inner apex and three near the outer margin. Anterior to the triangular plates is an arched plate about 130 µ long. It is more heavily sclerotised along its median axis. Marginal setae absent except for two apical stout and pointed apical setae on the margin of the anal cleft, the inner 16 µ long and nearly twice as long as the outer one, 9 µ. Ventrally, there is a group of 6 pairs of slender hair-like abdominal setae, situated anterior to the anal ring. The outer anterior pair is the longest, about 120 µ long, the rest short and variable, about 50 µ long. Derm pores, more numerous all round the margin than on the central region, and scattered irregularly. Dorsally 8-shaped derm pores are frequent and nearly uniform, about 4 µ in diameter, with thickened internal walls. The two pores are usually inclined to each other at a different angle, so that the double orifice characteristic of the 8-shaped pores is rarely found. Five pairs of circular, sive-like (cerebriform) plates, about 25 µ in diameter are arranged in a dorsal median double row extending along the median ridge on either side and more diverging anteriorly. Some specimens contain a sixth pair, one one either side outer to this row.

Male Puparium oval, much smaller and narrower than the female, about 1.5-2 mms. long, colour pale yellow and with clear transverse ridges.

Distribution : Common in Upper Egypt, but very few records were gathered from places near Cairo, Lower Egypt and the Oasis.

Host plants : Casuarinacaae (*Casuarina* spec.). Leguminoseae (*Acacia arabica*, *A. tortilis*), Moraceae (*Ficus carica*, F. *infectoria*, *F. nitida*), Myrtaceae (*Psidium guava*), *Rhamnaceae* (*Zyziphus spina-christa*), Salicaceae (*Salix* spec.).

Asterolecanium pustulans Ckll.

Asterodiaspis pustulans Ckll., *Journ. Inst., Jam.*, I, p. 143 (1892).
Planchonia pustulans Ckll., *Science Gossip*, XXIX, pp. 77 (1893).
Asterolecanium pustulans var. sambuci Ckll. *Entomologist*, XXXVI, p. 112 (1903).

Test of adult female, sub-circular or short ovate, with posterior extremity slightly produced; about 1.7 mm. long and 1.4 mm. wide, flat or slightly convex, colour varying from yellow to green, semi-transparent and glassy in texture, with a faint median ridge and faint transverse striations. The margin bears a continuous fringe of glassy filaments and similar filaments arise from its dorsum, sometimes sparse but almost giving quite a hairy appearance except before oviposition.

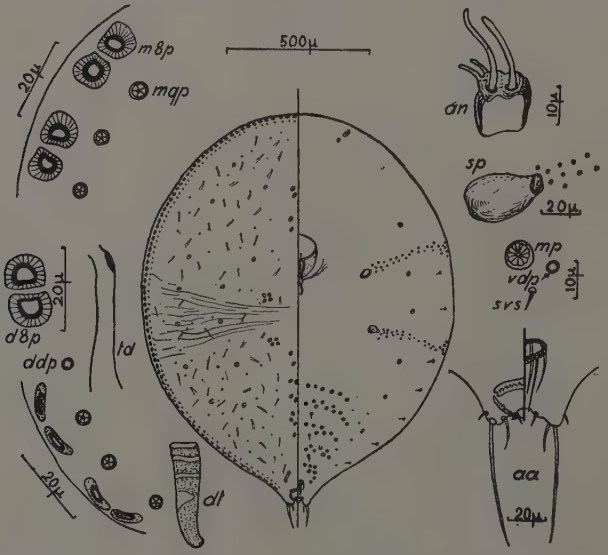

Fig. 2 : *Asterolecanium pustulans* Ckll. (*aa*, anal area; *an*, antenna; *d'8p.*, dorsal 8-shaped pores; *ddp*, dorsal disc pores; *m8p*, margina (8-shaped pores; *mdp*, marginal disc pores; *mqp*, marginal quinque-locular pores; *mp*, multi-locular pores; *sp*, spiracle; *svs*, submarginal ventral setae; *td*, tubular ducts; *vdp*, ventral disc pores).

ADULT FEMALE (Fig. 2), nearly circular with posterior end produced, about I.I mm. long and 0.9 mm. wide. Antennae, tubercular, about 15 μ in diameter, with two curved stout setae, slightly longer than the antenna itself. Legs wanting. Spiracles broad or circular internally and constricted externally, about 40 μ long. Stigmatic pores numerous and extending to the margin, the majority being 5 locular, but some are 9-11 locular. Anal ring cellular and heart shaped about 20 μ wide, with 6 anal setae, about 38 μ long, the outer pair being shorter about 20 μ long. The dorsal area is heavily sclerotised in the form of 3 anal plates, a transverse plate of about 30 μ long and 2 longitudinal plates about 15 μ long. Marginal setae, wanting. Apical setae, a long dorsal seta about 70 μ on outer anal lobe with 2 shorter setae one on either side about 11 μ long, another ventral shorter seta, 5 μ long, on inner anal lobe. Sub-marginal setae, short and pointed are present in a complete ventral row of about 12 pairs, each of about 6 μ long. A group of 3 pairs of similar ventral abdominal setae on posterior extremity in front of anal region.

DERM PORES : marginal 8-shaped pores in a single row all round the body, about 9 μ long, 6 μ wide and 9 μ apart from each other. These pores are more crouded near anterior end, but posteriorly the two halves of each pore are inclined to each other at an angle of about 130°. Inner to the 8-shaped pores is a row of 5 locular pores, about 2 μ in diameter, 11 u apart and 6 μ far from the 8-shaped pores. Inner to these is another row of minute disc pores 1 μ in diameter, 11 μ apart and 8 μ far from the 5 locular pores. Dorsally, there are somewhat bigger 8-shaped pores, about 12 μ long, scattered in an irregular fashion. In between are disc pores, 3 μ in diameter and tubular ducts 32 μ long. Ventrally, 8-shaped pores are less frequent, very few are found anteriorly near antennae, then there is a sub-marginal double row starting from just in front of the posterior spiracle and extending backwards. Near the posterior end they extend inwards in 5-6 transverse rows. Multi-locular pores, about 8 μ in diameter, are found in 3-4 groups in anal extremity. Disc pores, 3 μ in diameter, are also found with multi-locular pores.

DISTRIBUTION : The insect is widely distributed in this country, but with different degrees of infestation. The heaviest infestation is in the Fig. growing localities, as in the coastal regions, lower parts of the Delta and in Fayoum.

HOST PLANTS : The insect infests numerous host plants. It settles on the stem, green shoots, stalks of leaves, mid-ribs and sometimes on the fruits. It causes several plants to produce pits which conceal the body of the insect itself. The host plants recorded are : Amarantaceae (*Alternanthera* spec.). Anacardiaceae (*Mangifera indica*), Anonaceae (*Anona squamosa*), Apocyanaceae (*Nerium oleander*, *Carrissa edulis*), Bignoniaceae (*Jacaranda mimosaefolia*, *Tecomas mithii*), Boraginaceae (*Cordia mixa*), Caprifoliaceae (*Xiburnum tinus*), Cruciferae (*Brassica oleraea*), Leguminoseae (*Acacia decurrens*, *Cassia fistula*, *Bauhinia* spec., *Albizzia lebbeck*, *Acacia arabica*, *Caesalpinia* spec., *Cajanus indicus*, *Robinia pseudacacia*, *Sesbania aegyptiaca*, *Tamarindus indica*, *Pitheolobium*, *Prosopis*), Malvaceae (*Hibiscus esculentus*, *H. rosae*, *H. rosae-sinensis*, *H.* spec., *Abutilon* spec., *Gossypium* spec.), Meliaceae

(*Melia azedarach*), Moraceae (*Ficus carica*, *F. nitida*, *F. sycomorus*, *F. infestoria*, *Morus* spec.), Myrtaceae (*Eucaliptus*), Nyctaginaceae (*Bougainvillia* spec.), Oleaceae (*Jasminum* spec., *Olea europea*); Passifloraceae (*Passiflora quadrangularis*), Pittosporaceae (*Pittosporum* spec.), Pretiaceae (*Grivilia* spec.), Rhamnaceae (*Ziziphus* spec.), Rosaceae (*Crataegus* spec., *Eriobotria*, *Prunus persica*, *P. armeniaca*, *P. domestica*, *Pyrus communis*, *P. malus*, *P. cydoniae*, *Rosa spec.*), Salicaceae (*Salix* spec.), Sapotaceae (*Sapota acra*), Solanaceae (*Solanum* spec.), Sterculiaceae (*Guazuma tementosa*, *Sterculia* spec.), Verbenaceae (*Duranta* spec.), Vitaceae (*Vitis vinifera*).

Asterolecanium bambusae Boisd.

Chermes bambusae Boisd., *Insect Agr.*, III, pp. 260-262 (186).
Planchonia (*Asterolecanium*) *bambusae* Newst., *Ent. Mon. Mag.*, p. 75. (1897).
Planchonia bambusae de Charm., *Pr. Soc. Amic. Scien*, p. 42 (1899).
Asterolecanium bambusae var. *bambusulae* Ckll., *Amer. Nat.*, XXXI, pp. 588-592 (1897).

Test of adult female, oval, and clearly longer than wide, slightly produced posteriorly, about 2.5 mm. long and 1.8 mm. wide, convex, colour differs from pale yellow to green or brown, transparent, shiny, with marginal and dorsal filaments.

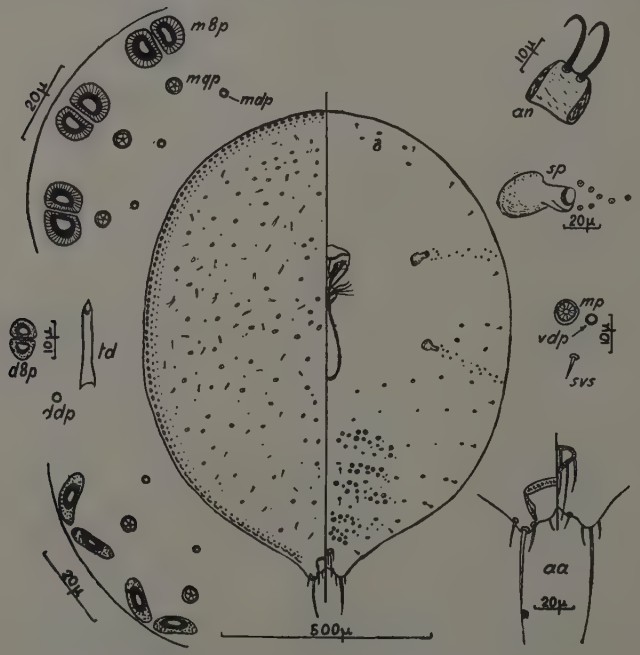

Fig 3 : *Asterolecanium bambusae* Boisd. (*dt.*, dorsal tube; rest as in Figure 2).

ADULT FEMALE (Fig. 3) sub-circular or broad oval, about 2.25 mm. long and 1.6 mm. wide. Nearly similar to *A. pustulans* Ckll., and differs in the following :

(*a*) in the margin the 8-shaped derm pores are accompanied by a single row of quinquelocular derm pores, the row of minute disc pores being absent; (*b*) dorsally, the 8-shaped pores are bigger, about 15 μ long, less frequent, more numerous towards median line. Tubular ducts more frequent and a bit longer about 35 μ long. A pair of dorsal tubes about 25 μ long is present near the posterior extremity; (*c*) ventrally, the antenna is provided with 2 long setae and 2 other short setae. Spiracles more circular and without constriction externally. Multi-locular derm pores more numerous, and more clearly arranged in rows. Disc pores less frequent. Sub-marginal 8-shaped pores in one row. Sub-marginal setae less frequent, about 7 pairs, and confined to posterior half of body.

DISTRIBUTION : More frequent in Lower Egypt and coastal regions.

HOST PLANTS : The following host plants were recorded : Caryophyllaceae (*Dianthus* spec.), Coniferae (*Thuja orientalis*), Euphorbiaceae (*Acalipha marginata*) Gramineae (*Bambusa vulgaris*, *Dendrocalamus giganteus*), Orchidaeceae (*Orchids*).

Pollinia pollini Costa

Coccus pollini Costa, *Atti* R. Ist. Incerrag., IV, p. 20 (1828).
Pollinia costae Targ., *Bull. Soc. Ent. Ital.*, I, p. 264 (1869).

FOLLICLE OF ADULT FEMALE : Females are rarely separate, but almost found in groups covered by a single black, highly convex or globose, very hard follicle. Beneath this follicle the insects are covered by a needle like, white crystalline secretion which firmly attaches them to the host plant.

ADULT FEMALE (Fig. 4), subcircular, 1.0-1.3 mms. long and 0.8-10. mms. wide. Antennae tubercular about 17 μ in diameter and bearing 5 terminal setae, about 18 μ long. Legs wanting. Spiracles broader internally and tapering outwardly, each with an anterir cluster of 23-30 stigmatic pores, which may slightly spread towards the margin. They are circular and 5-7 locular. Anal ring cellular, 25 μ wide, with 6 anal setae, about 26 μ long. No anal plates, but the body ends with two minute anal lobes. Marginal setae absent, except for apical setae, of which 3 dersal are present on the anal lobe on either side, and 2 ventral slightly apart from the lobe, all being stout and pointed. The outer dorsal is the longest about 27 μ long, the 2 inner dorsal shorter, about 10 μ long, and the ventral shortest, about 6 μ long. Body setae are present only in the posterior extremity and are more numerous dorsally than ventrally. They are very minute, 3.5 μ long, pointed and with conspicuous bases. Derm pores, scattered irregularly, and more numerous round the margin and in the posterior end where they attain a larger size. Dorsally 8-shaped derm pores are all of the same form. The double orifice occupies one corner, the rest of the opening being blocked. They are about 8 μ long and towards the posterior extremity range from 10-12 μ long. Ventrally, there are many disc pores scattered

in between the 8-shaped pores. They are circular, and about 5 μ in diameter. The ventral 8-shaped pores are of 3 types. The most common type is about 8 μ long and its double orifice is normal. The other two types are more numerous on the pos-

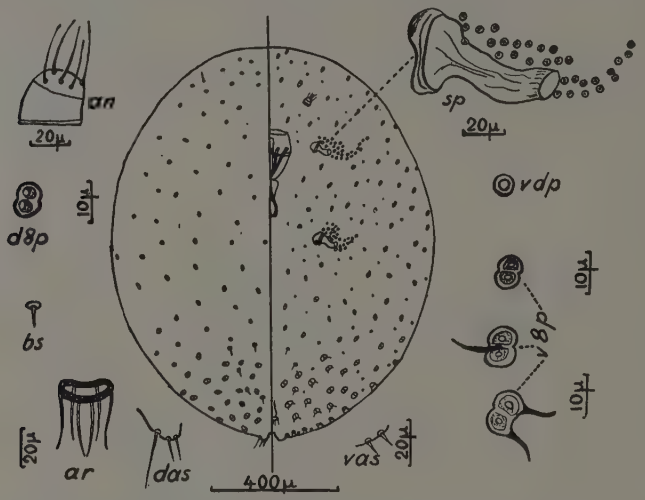

FIG. 4 : *Pollinia pollini* Costa (*das*, dorsal apical setae; *bs* body setae; *vas*, ventral apical setae; *v8p*, ventral 8-shaped pores; rest as in Figure 2).

terior end. In one there is a bristle-like projection coming out from between the two pores. In the other there are two projections coming out from both sides. These projections may approach the margin and give it a characteristic folded shape.

DISTRIBUTION : Coastal regions, Lower Egypt and Upper Egypt up to Minia, most numerous in the Olives growing localities, e.g. Fayoum and Maryout.

HOST PLANTS : Host specific and infests only *Olea europea* (Oleaceae). It prefers the places of furcation of shoots where numerous clusters of the black follicles could be seen. It causes the cracking of the bark and almost settles in these cracks.

ACKNOWLEDGMENTS

The writer wishes to express his thanks to the staff of the Plant Protection Department, Ministry of Agriculture, Egypt, for supplying him with infested samples from different localities of the Country, and for allowing him to make use of the Department's collection.

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THE MORPHOLOGY AND BIOMETRY OF THE *EULECANIUM CORNI* - GROUP, AND ITS RELATION TO HOST-PLANTS

[*Hemiptera-Homoptera* : *Coccoidea*]

(with 15 Text-Figures, and 8 Tables)

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INTRODUCTION

Eulecanium corni Bouché is a polyphagous scale insect which infests a large number of wild and cultivated plants. It presents a wide range of forms which when occurring on different host plants, are markedly different in size, shape, colour and degree of sclerotization. This fact has misled several authors and resulted in the publication of several long and confusing lists of synonyms.

The aim of this work was to decide whether we are really dealing with forms which are merely variants of a single species, differing in appearance because of differences in environment, or with totally different species or races. The work in this paper was carried out in the Imperial College field station, at Sunninghill, Berkshire, England. It is divided into three parts, namely, morphology, biometry and influence of host-plants.

I. MORPHOLOGY

In view of the insufficient descriptions given by the earlier authors, it was considered necessary to carry out a morphological study of this insect in its different stages collected from various host plants, namely *Taxus baccata* (Yew), *Rubus fruticosus* (Blackberry), *Prunus cerasus* (Cherry), *Prunus persicae* (Peach), *Pyracantha*

coccinea, *Cotoneaster microphylla*, *Ribes sanguineum* (flowering currant), and *Robinia pseudoacacia* (Acacia or Locustree).

The results of morphological observations showed that *E. corni crudum* on Yew is a different species and was given the name of *E. taxi* (vide *Bull. Soc. Entom. Egypte*, vol. XL, pp. 453-462). The remaining insects are merely different forms of *E. corni* Bouché, including the variety *robiniarum* occuring on *Robinia pseudoacacia*.

The description given below refers to the various stages of *E. corni*, and is based on the study of 30 different individuals selected at random for each stage and from each host plant. The measurements given represent the averages and ranges for all the specimens of the different forms studied.

The usual technique was used in the preparation of permanent mounts, using Acid Fuschin as a staining agent. Satisfactory results were obtained when boiling in caustic potash 10%, for 10, 20 and 30 minutes in cases of first, second nymphal stages and adult females respectively. In the case of old adult females, which are heavily sclerotised and highly convex, it was found more convenient to (a) leave the insects for 24 hours in Chloral Phenol (50/50 by weight Chloral hydrate and carbolic acid) before staining, (b) cut the margin of the insect's body under the binocular so that it lies flat on the slide.

The colours of the insects referred to in the text were tested according to the Color Standards and Nomenclature, by RIDGWAY.

The egg

The *egg* is oval in shape, white when newly laid, showing a very faint hexagonal pattern under higher magnification, changing to yellow when hatching; average 344 μ long, ranging from 311 to 358 μ. and 199 μ wide, ranging from 174 to 216 μ; without pores or caps, the nymphs pushing their way out on hatching from the anterior end causing the spliting of the shell along a mid-line.

The first stage nymph

Yellow, ovate, slightly tapering posteriorly where an anal cleft is present. Extremely thin and flat with distinct segmentation. Average 461 μ long (excluding antennae and caudal setae), ranging from 376 to 565 μ. and 245 μ wide, ranging from 193 to 301 μ. *Antennae* (Fig. 1) 6-segmented, 127 μ long, ranging from 118 to 136 μ (Fig. 1, *an*). Segments and their measurements as follows : (1) broadest, one seta, 18.8 μ long; (2) narrower than first but broader than the rest, two setae, 14-18.8 μ long; (3) with a slight constriction at distal end from which arise three setae, 28-33 μ long; (4) one seta, and (5) two setae, equal in length, 14 μ; (6) 33-38 μ long, seven setae, the apical longest. Antennal formula : 6,3, 1,2, (4,5). Ranges of measurements however allow some variations in this order. *Eyes* (*e*) placed one on either side on the margin of the body behind the antennae, dome-like, brownish and comparatively larger than in other stages. *Legs*, comparatively short, subequal, placed well within

the lateral margins of the body. The measurements of the parts of the metathoracic leg, expressed in microns, are as follows :

Measurements	Coxa		Trochanter and femur		Tibia		Tarsus	
	Average	Range	Average	Range	Average	Range	Average	Range
Length	40	33 - 47	67	61 - 75	46	38 - 47	32	28 - 38
Width	29	28 - 33	25	24 - 28	14	—	9	—

Coxa (*cx*) with two setae on its distal end; *trochanter* (*tr*) triangular, with one seta at its distal end; (*femur* (*f*) with two setae at its distal end; *tibia* (*tb*) with a single seta on its outer margin and two setae on its inner margin; *tarsus* (*ts*) with two setae on both outer and inner margins; *claw* (*cl*) comparatively long (14μ),

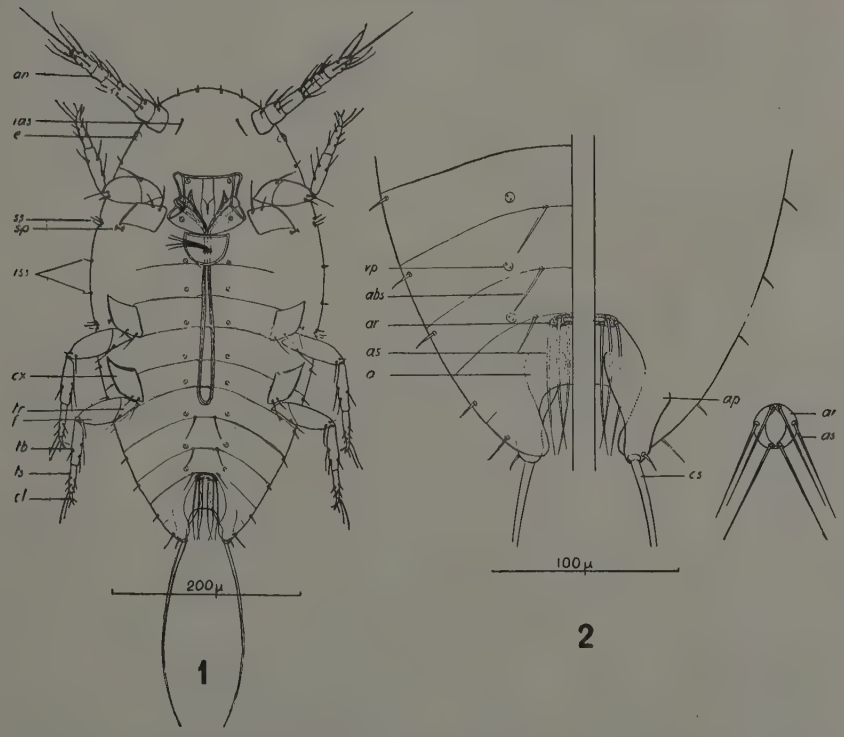

FIG. 1:First stage nymph, ventral *an*, antenna; *cl*, claw ; *cx*, coxa; *e*, eye; *ias*, inter-antennab setae; *iss*, inter-stigmatic setae; *sp*, spiracle; *ss*, stigmatic setae; *tb*, tibia; *tr*, trochanter; *ts*, tarsus). — FIG. 2 : Posterior end of abdomen of the first stage nymph (dorsal and ventral) and anal ring (*a*, anal opening; *abs*, abdominal setae; *ap*, anal protruberance (plate); *ar*, anal ring; *as*, anal setae; *cs*, caudal setae; *vp*, ventral pores).

and accompanied by a very slender pair of both digitules and tenent hairs of which the outer is slightly longer. *Spiracles* submarginal, ventral, a pair on either side near the insertion of the coxae of the prothoracic and metathoracic legs, not accompanied with stigmatic pores. *Mouth parts* well developed, and described in connection with the second stage nymph. *Anal opening* (Fig. 2, *a*) subterminal, slightly dorsal. *Anal ring* (*ar*) divided into two halves, each with three almost equally long (47 μ) *anal setae* (*as*). Overlapping the anal opening dorsally, are two membranous anal protruberances which form the anal plates (*ap*) in the following stages. They are more or less triangular in shape, with the anterior base incomplete. Posteriorly, they slightly exceed the length of the body, each ending with a very short external seta and a very long internal caudal seta (*cs*), about 190 μ long. *Ventral pores* (*vp*), bilocular, arranged in ten pairs extending along the mid-ventral line. *Ventral setae* : a pair of *inter-antennal setae* (*ias*) arises in between the antennae, close to their bases, and three pairs of *Abdominal setae* (*abs*) are arranged in two longitudinal rows in front of the anal cleft. *Marginal setae* : three short *stigmatic setae* (*ss*) arise ventrally from slight marginal depressions opposite to the spiracles, the middle one slightly longer. Similar short marginal setae are present all round the margin of the body, the longest of which is the nearest to the anal cleft. For comparative purposes, it was found more convenient to confine observations to the number of setae in between the stigmatic depressions, and which may be termed as the *inter-stigmatic setae* (*iss*).The number found in this stage is always 2.

The second stage nymph

Both sexes of the second stage nymph (Fig. 3) represent the hibernating stage. Its duration is very long, during which time it shows quite a marked amount of growth. The body is ovoid, slightly tapering anteriorly and broadest in the spiracular region. Length 0.986 mm. (0.777-1.295) at beginning of stadium, and 1.705 mm. (1.074-2.280) at end of stadium, corresponding widths being 0.539 mm. (0.391-0.739) and 0.990 mm. (0.593-1.371). Mean diameters ($\sqrt{\text{length} \times \text{width}}$) are 0.728 mm. (0.577-0.956) and 1.315 mm. (0.825-1.768), respectively. After moulting, colour starts as white, and darkens gradually until finally it becomes Buff-Pink d. 11' orange, with many faint brownish striations on both sides of its dorsum . *Antennae* (Fig.4,A) six - segmented, averaging 185 μ long (151-207) and 196 μ (165-221) at beginning and end of stadium, respectively. Antennal formula 3, 6, (1,2), (4,5). The ranges of measurements however allow of some variations, the most common of which is, for the second segment, to be slightly longer than the first. The third segment shows a marked growth in this stage, and within its distall half there is always a faint oblique superficial suture, which is sometimes so clear as to appear as two segments. The distribution of setae is similar to that of the first stage. *Legs*, more or less equal in length about 400 μ, except that the coxa of the prothoracic leg is shorter than in the other two legs. The setae arising from the different segments are exactly the same as in the first stage nymph. The digitules are slightly dilated with truncate extremities,

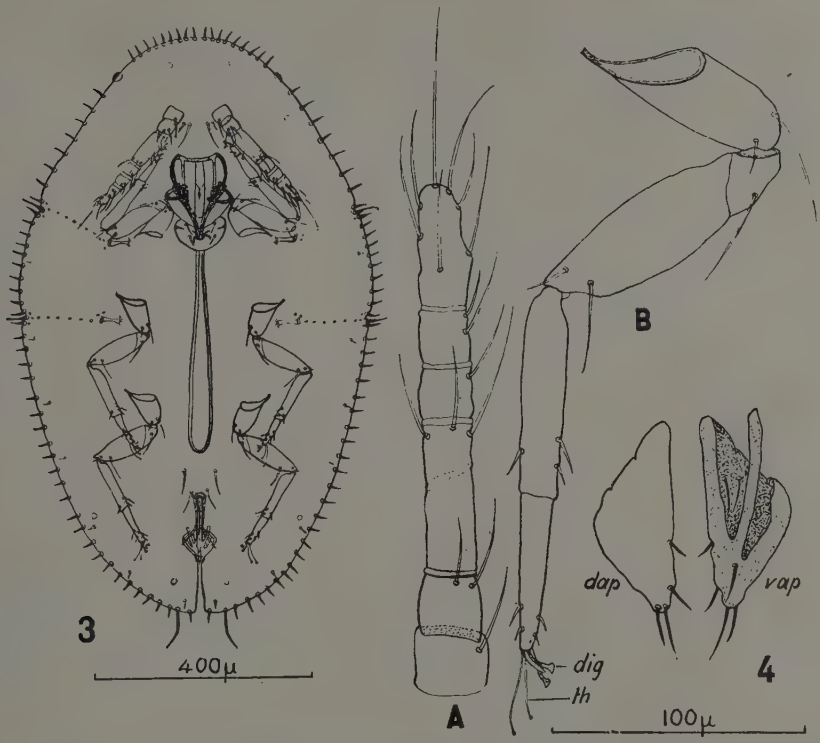

FIG. 3 : Second stage nymph, ventral. — FIG. 4 : Various parts of the body of the second stage nymph : A, antenna; B, metathoracic leg (*dig*, digitules; *dap*, dorsal side of anal plate ; *th*, tenent hairs; *vap*, ventral side of anal plate).

and the two tenent hairs project well beyond the claw, the outer being longer. *Spiracles* (Fig. 5, *sp.*) present in practically the same positions as in the first stage nymph, but accompanied with spiracular furrows, with an irregular row of quinquelocular *stigmatic derm pores* (*sdp*). These pores secrete a powdery waxy secretion which is very clear in living specimens and accumulates in clusters around the stigmatic setae. *Head skeleton and mouth parts* (Fig. 6), well developed and more chitinised than in the first stage. The *pharynx* (*ph*), and the bases of the *mandibles* (*md*) and *maxillae* (*mx*) are contained in the typical Coccid "chitinised box" or head skeleton. On each side there are two semi-circular chitinised apodemes attached anteriorly at right angles to one another and lying in vertical planes. These are the ventral and dorsal *anterior arms* of the tentorium (*vaa* and *daa*) This structure is connected anteriorly to its partner by the *dorsal transverse arm* of the tentorium (*dta*). Posteriorly, they are connected on each side to two levers (l_1 and l_2) which

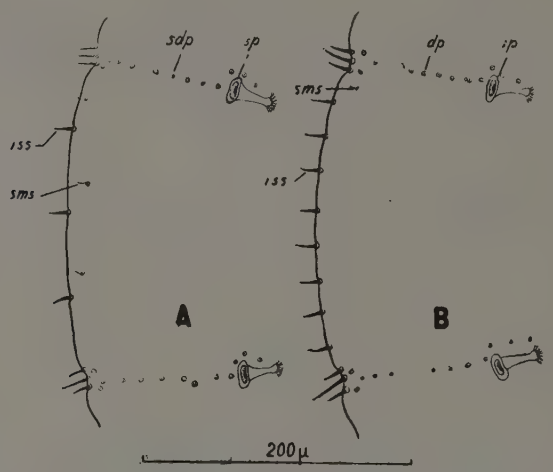

FIG. 5 : Ventral aspect of the margin of the thorax : A, *E. corni*; B, *E. taxi* (*iss*, inter-stigmatic setae; *sdp*, stigmatic derm pores; *sms*, submarginal ventral setae; *sp*, spiracle).

form a more or less horizontal semi-circle. These levers support the anterior edges of the two separate halves, which unite behind to form the membranous *sheathing cone* (*sc*) containing the bases of the mouth-parts. The outer margin of this cone is supported on either side by the *posterior arm* of the tentorium (*pa*). The conical bases of the mandibles and maxillae on each side, lie freely within the cavity of the

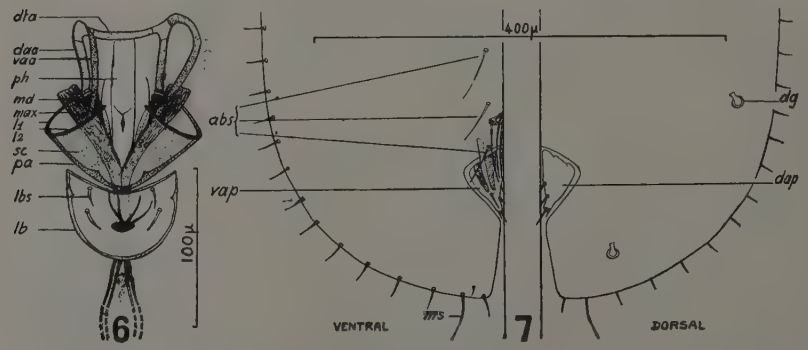

FIG. 6 : Head skeleton and mouth parts of the second stage nymph (*daa*, dorsal anterior arm of tentorium; *dta*, dorsal transverse arm of tentorium; *l*1 and *l*2 levers; *lb*, labium; *lbs*, labial setae; *mx*, maxillae; *md*, mandibles; *pa*, posterior arm of tentorium; *ph*, pharynx; *sc*, sheathing cone; *vaa*, ventral anterior arm of tentorium). — FIG. 7 : Posterior end of the abdomen of the second stage nymph (*abs*, abdominal setae; *dap*, dorsal side of anal plate; *dg*, dorsal gland; *ms*, marginal setae; *vap*, ventral side of anal plate).

sheathing cone, slightly projecting from it anteriorly. They come together at the junction of the two halves of this sheath and are adpressed to form a tube which passes backwards into the labial cavity forming the usual loops, and passing out of the body again through the labium. The *labium* (*lb*) is heavily chitinised, monomerous, and more or less semi-circular in shape. Its external opening is smooth and it bears, ventrally, two *labial setae* (*lbs*) on either side of the opening. *Anal opening* invaginated, with a cellular *anal* ring, which is distinctly divided into two halves, each with three long *anal ring setae*. *Anal plates* (Figs. 4 and 7, *dap* and *vap*) triangular, slightly sclerotised, lying along the anterior part of the anal cleft, with their apices directed laterally, while their inner bases are parallel. They measure 73μ long (61-85) and 35 μ wide (28-38) at beginning of stadium and 80 μ long (66-94) and 36 u wide (28-47) at end of stadium. The caudo-lateral margin is slightly longer than the cephalo-lateral margin. Dorsally, they are convex and smooth and bear four setae, two inner and two posterior one of which is longer and is supposed to represent the long caudal seta of the anal protuberance in the first stage nymph. Ventrally, they are concave, with their edges bent inwards. From the posterior margin of this bent edge arises a tendon-like structure which extends anteriorly and exceeds the anal plate in length. It is probable that this process helps in holding the anal plate in position. There are three setae on the ventral surface of each plate, two anterio and a single posterior one lying on the bent edge behind the tendon-like process. *Dorsal glands* (Fig. 7, *dg*) two groups on the anterior and posterior extremities of the insect, each consisting of two pairs. They secrete very long and exceedingly delicate glass-like filaments, which appear highly iridescent under strong reflected light. In very few specimens a fifth pair is present one on each side opposite to the inter-stigmatic space (5 cases from 210 specimens examined). This is not a constant character, and it seems that this pair, if present, is not functional. Not a single insect has been observed with filaments emitted from its sides. *Ventral setae* : a row of *submarginal setae* (Fig. 5) which are widely dispersed, fewer in number and much smaller than the marginal setae, two pairs of *inter-antennal setae* the outer of which is much shorter, occupy the same position as in the first stage nymph, and three pairs of *abdominal setae* (Fig. 7, *abs*) the third of which appears to be behind the anal ring which is slightly shifted forward in comparison to its position in the first stage nymph. *Marginal setae* more numerous than in the first stage nymph, more or less equidistantly dispersed, except on both sides of the eyes, where a slightly wider bare area is present. The number of *inter-stigmatic setae* (Fig. 5, *iss*) increases in this stage to 8 ranging from 6 to 12. The second marginal seta (Fig. 7, *ms*) from the anal cleaft is much longer than the rest.

The adult female

The adult females (Figs. 8, 9, and 10) in this stage grow rapidly and reach many times their original size. It is in this stage that the insects are mostly affected

by the host plant, and show a great variety of sizes, colours and forms, a point which will be fully discussed below.

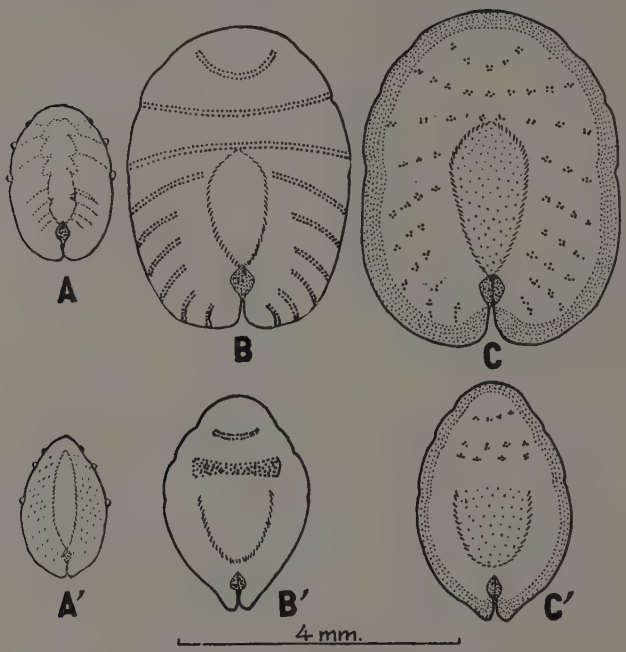

FIG. 8 : Diagram showing the form of the adult and the striations of the dorsum : A, young adult of *E. corni*; B, adult during oviposition; C, adult after oviposition; A', B', C', similar stages of *E. taxi*.

The *young adult*, in general, is rather oval in shape, with the anterior extremity slightly narrower. The anal cleft is long and narrow with more or less parallel sides. The body is slightly convex, and the colour in general is buff. The central dorsal carnina is paler in colour and its margin is slightly darker with some transverse striations appearing gradually. When oviposition starts, the insects become darker, more convex, and the transverse dorsal striations appear very clearly. There are 7 to 9 transverse striations. The anterior one occupies the cephalic region and is clearly curved backwards from its centre. The next two are very slightly curved, and occupy the thoracic region. The remaining ones are not as complete as the first three, but are just oblique striations on the lateral margin of the abdomen, extending posteriorly to the anal plates, and hardly reaching the central dorsal carina. Towards the end of oviposition, these striations begin to fade gradually until they completely disappear by the end of this period. The colour changes in

general to brown with different shades on different host plants. The dorsal central carina remains very clear with many confluent punctures on either side. Although the different forme occurring on different host plants show a great variation of size, form, and colour, yet the many parts of the body such as the appendages, spiracles and setae remain nearly the same, and show no appreciable growth during the rapid growth of the bodies of the adults.

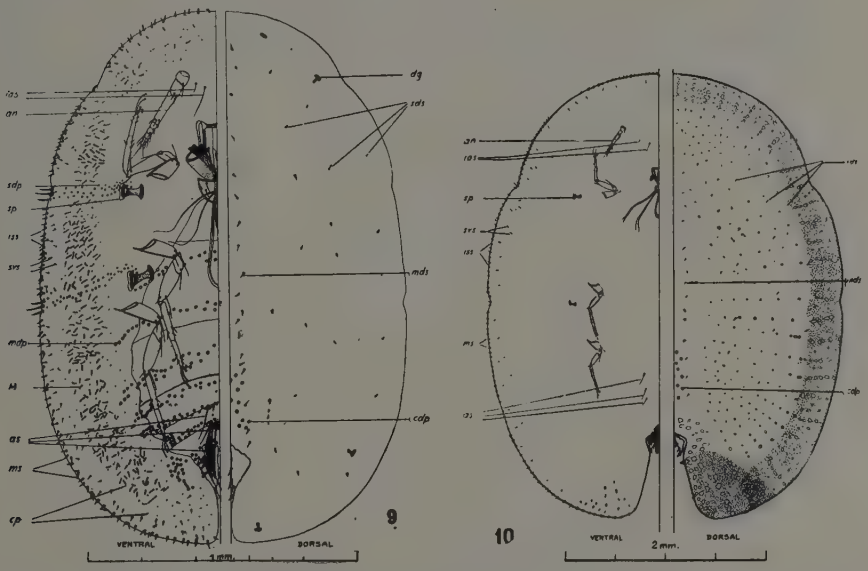

FIG. 9 : Young adult. (*an*, antenna; *as*, abdominal setae; *cdp*, circular dorsal pores; *cp*, small circular pores; *dg*, dorsal glands; *ias*, inter-antennal setae; *iss*, inter-stigmatic setae; *mdp*, multilocular derm pores; *mds*, mid-dorsal setae; *ms*, marginal setae; *sdp*, stigmatic derm pores; *sds*, submarginal dorsal setae; *sp*, spiracle; *svs*, submarginal ventral setae; *td*, tubular ducts). — FIG. 10 : Old adult (same abreviations as in Figure 9).

The *antennae* (*an*) are seven-segmented. This increase in number is undoubtedly caused by the rapid growth of the third segment of the second stage nymph and the conversion of the superficial segmentation which it usually attained to a true segmentation. Average length 300 µ, ranging from 259-344 µ. Antennal formula 4, 3, 7, 2, 1, (5, 6). Different arrangements may occur owing to the great variations of the third and fourth segments. Excluding the third segment, which in fact represents the proximal non-setose half of the third antennal segment of the second stage nymph, the setae are exactly the same as in the second stage nymph. The constriction appears in this stage in the distal end of the fourth segment which actually represents the distal half of the third segment in the second stage nymph. *Legs*, slender; very similar to those of the second stage nymph in structure and distribution of setae,

about 600 μ long. *Spiracles* (*sp*) with wide spiracular openings and thicker arms, and more numerous stigmatic pores which are mainly quinquelocular, occasionally 6, 7 or 8-locular, especially those near the marginal stigmatic depressions and around the spiracular openings. *Anal opening* invaginated, *anal ring* cellular, distinctly divided into two halves, each half with three *anal ring setae*. *Anal plates*, the same as in second stage nymph, measuring about 150 μ long and 80 μ wide. The *ventral pores*, show clearly in the young adults but are almost always much less apparent in old adults, and consist of the three following types : (a) *multilocular derm pores* (*mdp*) 8-10 locular, arranged in seven transverse bands, the most posterior of which bending around the anal cleft and composed of numerous pores, anteriorly the number of pores in the bands gradually decreases; (b) *tubular ducts* (*td*), occupying a comparatively wide submarginal zone all round the body, except at the anterior extremity where they are less numerous, and on the anal cleft where they are absent; (c) *small circular pores* (*cp*), with circular external opening about 3 μ in diameter leading into a conical sclerotized depression about 5 μ deep with a short membranous internal duct, are scattered among the tubular ducts being especially numerous in the cephalic area and around the anal cleft. The previously mentioned two groups of *dorsal glands* (*dg*) are present in a rudimentary condition in the young adult, but invisible in the old adult. A median group of *simple circular dorsal pores* (*cdp*), anterior to the anal opening, composed of 16-23 pores (average 17); the distance between the anterior extremity of the anal plate and the nearest pore being 109 μ in the young adult, ranging from 71 to 141 μ. This distance increases in the old adult, owing to the stretching of the body, to 320 μ, ranging from 188 to 518 μ. *Ventral setae* : two pairs of inter-antennal setae (*ias*) occupy the same situation as in the second stage nymph; three pairs of *abdominal setae* (*as*) becoming widely separated from anal ring due to the stretching of the body, and are now situated nearly opposite to the group of the circular dorsal pores; a single or partly double row of *submarginal ventral setae* (*svs*), shorter and thineer than marginal setae, and more numerous on the sides of anal cleft. *Dorsal setae* : a mid-dorsal row (*mds*) consisting of about 17 pairs, extending all along the mid-dorsal line of the body and three rows of submarginal dorsal setae (*sds*) on either side consisting of about 7, 6, 5 setae respectively. *Marginal setae* (*ms*) greatly increase in number and become more stout, the number of the *inter-stigmatic setae* (*iss*) increase to 18 ranging from 11 to 28. These setae appear comparatively very minute in the old adults, they break off easily and look more widely dispersed. The marginal seta second to the anal cleft is still somewhat longer than the rest of the marginal setae.

The male

Among the twenty-two different host plants, harbouring *E. corni* and examined by the present author in Great Britain, the males were not found except on one plant, namely *Cotoneaster microphylla*, from the Royal Horticulture Society Garden

at Wisely. For the description of the different stages of the male see *Bull. Soc. Entom. Egypte, XL*, 1955, pp. 119-126.

II. BIOMETRY

The morphological studies of *Eulecanium corni* and *Eulecanium taxi* has necessarily implied a detailed biometrical investigation. The literature on the biometry of these insects is very scarce. The only author who has dealt with such studies is EBELIG (1938). He studied the effect of the host plant on the morphological variations in *E. corni*. He dealt with the forms occurring on Christmasberry (*Photinia arbutifolia*), Apricot (*Prunus armeniaca*) and Alder (*Alnus rhombifolia*). EBELIG selected certain ratios, e.g. total length of antennae to the length of the fourth segment, total length of the leg to the length of the tibia, and height of the body of the adult female to its length, which he found to be significantly different in these forms and which were affected by the host plant. The writer has not been able to find such fundamental differences in the morphology of the different forms studied in this country. One of EBELIG's criteria was found to produce a discrimination the nature of which is discussed below.

The host plant mainly influences the size, colour and fecundity of the insects in their adult stages as will be shown under Section III : The influence of the host plant.

The morphological characters which have been chosen to separate *E. taxi*, from *E. corni* have proved to be consistent in all the studied forms of the latter.

The technique followed in this part of the work was to take the measurements of the body and its different parts, in 30 different insects collected at random. This process was repeated with each form in all different stages. The forms examined were those dealt with in Section I of this work.

All measurements are given in terms of the divisions of the micrometer eye-piece, when the high power objective was used (eye-piece — 6, objective 1/6 inch). Each division corresponds to 4.71 μ. In the case of the old adults, owing to the necessity of cutting the edges of the bodies before mounting, the dimensions of the body were taken before preparation and are expressed directly in millimeters. In order to obtain the length and width, a squared background was used under the binocular, while a spherometer was used to measure the height.

The data obtained from the old adults, showed marked variations and were used for the statistical analysis. Some data were missing for individual insects, as it was extremely difficult to get preparations showing all structural details. This caused the numbers of measurements to be unequal in some cases and so elimination of some data by random selection was carried out, as it was found more convenient to work with equal numbers.

The statistical analysis of all the characters tried was systematically as follows: (*a*) simple analysis of variance between forms on different host plants (including

E. taxi on *Taxus baccata*) ; (*b*) the estimation of the least significant interval to separate off differing forms; (*c*) careful sub-analysis of the data by the comparison of individual means of forms inseparable by the above method (see TUKEY, 1949).

The following two criteria were tried to distinguish between the different host forms.

1. *Mean diameter*

If the ventral surface area of the insect in all its stages is considered as an ellipse, then the mean diameter of this area should be equal to $\sqrt{L.W.}$ where L is the length of the insect and W is its width. The means of the mean diameter were calculated for all the stage of *E. taxi* and all the forms of *E. corni* and are given below expressed in terms of divisions of micrometer lens.

Host Plant	Egg	First stage nymph	Second stage nymph		Adult female	
			Young	Old	Young	Old
Texus baccata	50.8	65.2	135.8	237.2	319.6	502.0
Rubus fruticosus	55.6	62.7	139.3	285.8	310.3	710.6
Prumus persicae	55.6	74.3	160.4	279.9	342.3	822.0
Prunus cerasus	55.6	72.4	161.7	249.3	344.3	833.7
Pyracantha coccinea	55.6	71.4	153.0	297.1	370.7	652.8
Cotoneaster microphylla .	55.6	79.7	153.0	286.2	295.2	711.2
Ribes sangnineum	55.6	64.2	153.0	226.4	281.4	511.5
Robinia psendoacacia ..	55.6	75.7	162.0	329.2	372.7	1027.9

The increase of the mean diameter in each case from one stage to the other, represents the growth of the insect. When plotting the mean diameter curves for all the stages (Fig. 11), the following conclusions could be drawn : (*a*) the mean diameters of the young stages of the different forms from the egg to the old second nymphal stage are greatly overlapping and are practically inseparable; (*b*) the influence of the host plant on growth starts to show from the young adult stage onwards and is clear in the old adult stage ; (*c*) the lowest value of the mean diameter in the old adult stage is that of *E. taxi* on *Taxus baccata*, the highest is that of *E. corni* or *Robinia pseudoacacia*, with all the other forms lying in between these extremes; (*d*) some of the forms are nearly similar in the value of their mean diameters (old adults), e.g. the forms on *Taxus baccata* and *Ribes sanguineum*, the forms on *Rubus fruticosus* and *Cotoneaster microphylla*, and the forms on *Prunus persicae* and *Prunus cerasus*.

2. *Volume coefficient*

The height of the insect in the young stages is very small and almost equal in all the different forms. It also starts to increase rapidly in the adult stage showing a great deal of variation in the different forms. If the shape of the insect is considered as a semi-ellipsoid or even as hemispherical, then the volume of the insect is equal to $\frac{1}{2} \times \frac{4}{3} \pi \frac{L}{2} \times \frac{W}{2} \times H$ (where L is the length, W is the width and H is the height of

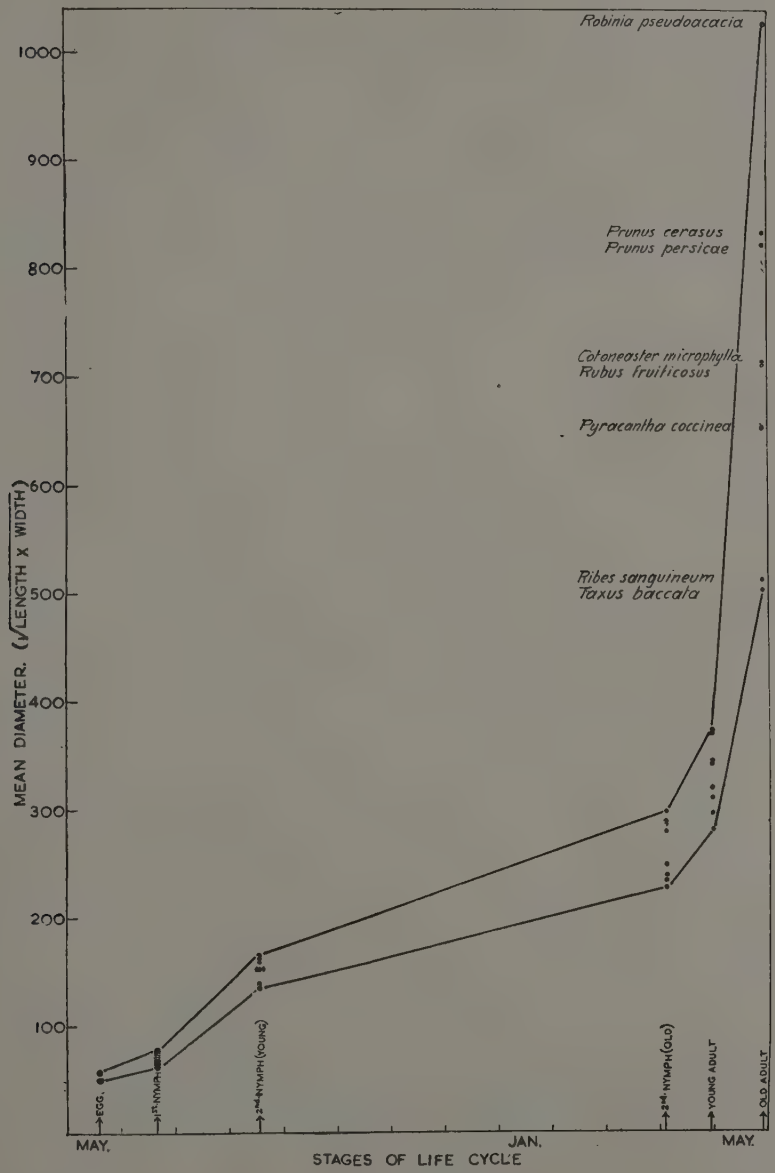

FIG. 11 : The growth of the insect represented by the increase of its mean diameter in the different stages as shown in forms occurring on eight different host plants.

the insect) or in other words words it is equal to $\frac{1}{6}\pi$ L.W.H. Since $\frac{1}{6}\pi$ is a common factor, then the value L.W.H., could be taken as a detached coefficient representing the volume of the insect.

The following Table includes the values of the averages and ranges of such volume coefficients of the differents forms expressed in millimetres.

Host forms	Averages	Ranges
Taxus baccata	8.39	4.90 - 12.96
Rubus fruticosus	23.25	11.62 - 38.08
Prunus persicae	34.78	19.38 - 64.40
Prunus cerasus	31.94	16.20 - 48.00
Pyracantha coccinea	15.53	7.56 - 29.11
Cotoneaster microphylla	21.70	13.87 - 41.80
Ribes sangnineum	8.83	3.30 - 22.04
Robinia pseudeacacia	64.48	50.11 - 84.48

Plotting the frequency curves (Fig. 12) of the volume coefficient for the different forms, the following conclusions could bc drawn : (*a*) a great deal of

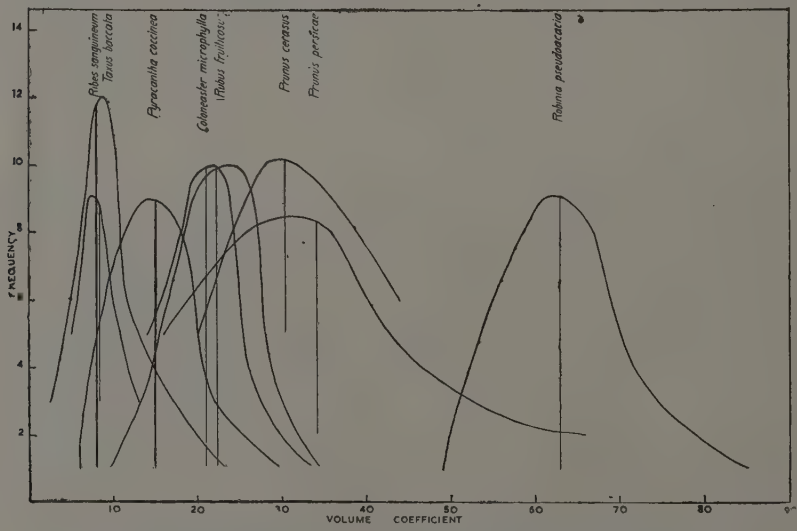

FIG. 12 : Frequency distribution curves of *E. taxi* on *Taxus baccata* and forms of *E. corni* on seven different host plants according to their volume coefficients.

overlapping exists between the volume coefficients of different forms ; (*b*) the shape of the frequency curves differs in different forms, from a narrow to a wide curve. Such differences in spread may reflect to a certain extent on the habitat of the insect.

For insects whose distribution curve is narrow the habitat is either restricted to one part of the plant as in the case of *Taxus baccata* where the insects are mainly confined to the leaves, or is represented by a small bush as with *Rubus fruticosus* or *Ribes sanguineum*. In the second case the habitat is usually a big tree, as with *Prunus* spp. and *Robinia pseudoacacia*.

On applying the analysis of variance to the volume coefficients of different forms, the standard error was ± 1.351 and the least significant interval 3.744. When applying TUKEY's method for comparison of individual means, it was found that the different forms fall according to their volume coefficients into the following five groups :

Group a, containing the forms on *Taxus baccata* and *Ribes sanguineum*.

Group b, containing the form on *Pyracantha coccinea*.

Group c, containing the forms on *Conteneaster microphylla* and Rubus *fruticosus*.

Group d, containing the forms on *Prunus cerasus* and *Prunus persicae*.

Group e, containg the form on *Robinia pseudoacacia*.

From the above study it appears that it is not safe to rely on the dimensions of the insect or on its volume in relating it to a certain host plant, a great deal of overlapping being present in both criteria. Thus other characters had to be studied and statistically analysed.

Six characters were tested, three of which were those used by EBELIG for a similar purpose, i.e. the ratio of the total length of the metathoracic leg to the length of the tibia, the ratio of the total length of the antenna to the tength of the fourth antennal segment, and the ratio of the height of the adult insect to its length. The other three characters were chosen because they seemed to indicate ways in which the forms appeared to differ. These are, the number of the inter-stigmatic setae, the number of the circular dorsal pores, and the ratio of the distance between the anal plates and the proximate circular dorsat pore to the length of the body.

1. — The ratio between the length of the antenna and the length of the fourth antennal segment. Standard error ± 0.0566. Least significant interval 0.157. The only form in which the difference of neans exceeded the least significant interval was the *E. taxi* on *Taxus baccata*. When eliminating this form and comparing between the individual means of the remaining forms not a single one could be distinguished from the others by the criterion used here.

2. — The ratio between the length of the metathoracic leg and the length of the tibia. Standard error ± 0.0295. Least significant interval 0. 082. Again the only separable form was that of *E. taxi* on *Taxus baccata*, no other form provided evidence to be distinguishable from the remainder by the criterion used here.

3. — The ratio between the height of the adult insect and the length of the body. Standard error ± 0.012. Least significant interval 0. 033. None of the forms separated according to the least significant interval. When comparing between individual

means, the form on *Prunus persicae* was the only form distinguishable from the remainder by this criterion, a point which is fully discussed below.

4. — Mean number of inter-stigmatic setae. The analysis of variance showed no significant difference between the forms of *E. corni*. *E. taxi* was not included in this anlysis as it has a clearly less number of these setae.

5. — Number of circular dorsal pores. Standard error ± 0.3289. Least significant intervat 0.92. Again the only form which separated off was that of *E. taxi*, the other forms providing no evidence to be distinguishable from the remainder by this criterion.

6. — The ratio between the distance of the nearest circular dorsal pore to the anal plate and the length of the body. Standard error ± 0.0021. Least significant interval 0.0059. The only separable form was again *E. taxi*, the remaining forms being inseparable from each other.

EBELIG'S criterion (height/length) distinguishes the form on *Prunus persicae* as a separate group. This distinction is not consistent with those of the remaining five criteria investigated, but its nature is made clear by consideration of the discrimination effected by the criterion H.L.W. Any discriminating character will provide information about both heritable and non-heritable variation.

These characters used here which consistently distinguish *taxi* from *corni* are of such a kind as to justify the raising of this distinction to the specific rank.

These characters may be considered good discriminators for heritable differences. The use of the volume coefficient (H.L.W) as a discriminating character leads to the separation of several forms of *Eulecanium* and it seems likely, both because of the number of the discriminations effected and because of the nature of the volume coefficient, that such differences are based over-whelmingly on the nutritional and the other environmental history of the insect. Some characters are likely to fall neither into the group sensitive to heritable variations nor into that sensitive to non-heritable variations. EBELIG'S ratio height/length seems to be such a character. This is because it is not the best measure of nutritional status available, as can be seen by the fewer differences between groups it distinguishes, than the more natural volume coefficient. The reasons for this are that being in the form of a ratio it (*a*) tends to minimise the differences and (*b*) is more closely associated with the convexity i.e. with the shape of the insect, rather than with the volume.

III. THE INFLUENCE OF THE HOST PLANT

To study the influence of the host plant on the morphology and development of the *E. corni*-group, two different types of observations were necessary. The first was to examine the largest possible number of different forms of this insect living in nature on different host plants and record the variations observed. This study (*cf.* Section I and II) led to the conclusion that the fundamental morphological

structure is the same in these different forms, and that the influence of the host plant shows only in the colour, shape, size and fecundity of the insect. The second was to carry out a set of experiments, in which the different forms were transferred in their different stages from one plant to the other, to see how far the variation of these characters was affected.

Several authors have studied this side of the problem, and the following is a brief summary of their conclusions. MARCHAL (1908), carried out a set of experiments on *Lecanium robiniarum*, in which he transferred *E. corni*, from Peach to a Locust tree (*Robinia pseudocacia*), and *Lecanium robiniarum* from Locust tree to Peach, Rose, and Vine. He concluded that the fundamental morphological structure is the same in both, and that the effect of the host plant was only to influence the colour and size of the insects. He succeeded in the former transfer, but met difficulty in the latter. Thus he considered *Lecanium robiniarum* as a variety of *E. corni* and gave it the name of *Lecanium corni* var. *robiniarum*.

VOUKASSOVITCH (1930) carried out a set of transferring experiments in which he transferred *E. corni* from Peach to several other host plant, e.g. Walnut, Cherry, Quince, Pear, Apple and Locust. His final conclusions were :

(a) That the scale insect *E. corni* presents a great degree of adaptability to different types of food especially during its early periods of development; (b) the change of food is normally accompanied by mortality which was always higher than on the original Peach; (c) the development was the same, with one generation a year; (d) no great morphological or biological variations could be observed, and the only characters which were affected were, the form, the colour and the volume of the insect. He obtained smaller volumes from the form on Apple and larger volumes from the form on Locust. He states that the latter is closely similar to the form of *Lecanium corni* var. *robiniarum*.

EBELIG (1938) did transferring experiments from apricot to Christmasberry and vice versa and from alder to apricot. Besides the variations is size, he found also that there were some structural variations affected by the host plant, a point which has been previously discussed in Section II.

SAVESCU (1944), after carrying out a set of transferring experiments of both *E. corni* Bché and *E. coryli* L., called the different forms of both, ecological forms. He stated that the morphological transformations which occurred are dependent on the quantity and quality of the food of the insects, or in other words on the chemical composition of the cell sap, which varies from one plant to the other, from one season to the other, and even in the same season from one vegetative organ to the other. These caused the variation in the ecological forms in size, colour, number of generations, etc.

(A) Forms on their natural host plants

1. *Colour, shape and dimensions*

The writer examined 22 different forms of *E. corni* on their natural host plants

and recorded their colours, shapes and the averages and ranges of their dimensions, so that they may be refered to in the transferring experiments.

2. *Size*

The volume of the adult insects is highly affected by the host plant. Some forms are exceedingly small as those on *Ribes sanguineum* and *Prumus domestica*, others are large as on *Rosa* sp. and *Robinia pseudoacacia*, with a wide range of sizes in between. It has been shown in section II, that when applying the volume coefficient (L.W.H.) test to eight different forms, they were seperable into five groups only, some of the forms being indistinguishable on a basis of their volume coefficient. Thus it is not safe enough to relate any one of the forms to a certain host plant according to its volume coefficient. However, the frequency curves of the volume coefficient in these forms have helped in showing the values at which the volume coefficient of each form stands, and the extent of overlapping. A further discussion of this point will be given when dealing with the transferring experiments.

3. *Fecundity*

The reproductive potential or in other words the number of eggs produced by the adult female has proved to be markedly different in the forms occurring on different host plants. Six host plants were tested for this purpose. Fifteen insects were taken at random from each host plant, and the total number of eggs laid by each was counted and the dimensions of the insect itself were estimated.

Taking L.W.H., as the detached volume coefficient of the insect, it can be shown that on each host plant, the number of eggs produced by the insects is positively correlated with this coefficient. The regression coefficient for each host plant was calculated by the normal method, and the data is given in the following Table :

Host Plants	Volume coefficient		Number of eggs		Regresion coefficient
	Average	Range	Average	Range	
Taxus baccata	8.8	5.9 - 11.6	343	152 - 543	69.31
Rubus fruticosus	23.4	11.1 - 36.1	1777	1168 - 2413	47.80
Prunus persicae	40.7	21.6 - 89.1	2394	2016 - 3409	20.78
Prunus cerasus	30.9	17.3 - 46.2	1125	816 - 1507	20.16
Pyracantha coccinea	17.6	9.8 - 29.1	208	128 - 314	10.08
Cotoneaster microphylla ..	21.7	15.3 - 31.6	1764	1503 - 2218	42.08

The regression lines are given for comparison in Figure 13. This shows that the host plant affects fecundity of the insects irrespective of body size, e.g.both *Cotoneaster microphylla* and *Rubus fruticosus* produce more eggs than *Prunus cerasus* in spite of having a smaller volume coefficient.

It is also interesting to note that the regression line for *E. taxi* on *Taxus baccata*, has a distinctly different slope.

This apparently independent effect of the host plant on the fecundity of insects was checked by the method of the analysis of variance with co-variance. This method compared the effect of plant on fecundity after the removal of the factor of body size, and showed it to be highly significant.

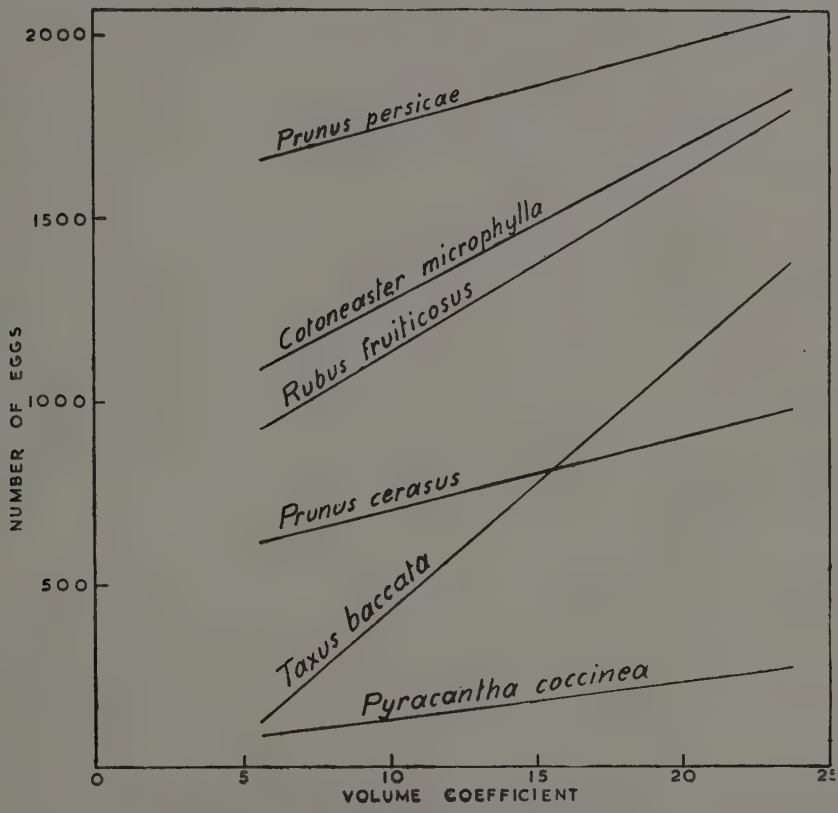

FIG. 13 The regression lines of the fecundity "number of eggs" according to the volume coefficient, in *E. taxi*, and five different forms of *E. corni*.

To summarise these results, both the body size and the fecundity of insects are independently affected by the host plant. The effect on fecundity may be more marked on some plants than the variation of the body size.

(B) Transferring experiments

Method and Technique

For transferring the insects from one host plant to the other, the following four methods were used.

(*a*) In the field

1. — Leaves infested with the second stage nymphs were collected from the stock host plant and were tied to one of the twigs of the new host plant. This part was then surrounded by a celluloid cylinder attached by tying its sleeve-like muslin ends round the twig. The joints were sealed with small pads of cotton wool. The muslin ensured adequate aeration of the cylinder. When the infested leaves started drying, the nymphs usually migrated to the twig of the new plant; where they settled. However, this method never gave satisfactory results due to the fact that many of the nymphs failed to migrate to the new host because of the prevailing low temperature which almost caused their immobilisation. The percentage of success was very low.

2. — Slivers of bark on which the adult females were lying, were removed from the original host plant with a knife, nearly at the end of oviposition. These were attached to the twigs of the new host plants and were surrounded by celluloid cylinders as in the previous method. When the eggs hatched, the crawlers spread on to the new twig where they settled. This method gave very satisfactory results and several insects succeeded in settling on the new plant, in spite of the fact that the actual percentage of success could not be estimated. It also allowed the insects to feed on the new host from the very beginning of their lives, and was better than the first method in this respect, where the insects fed for a part of their lives on the original host.

(*b*) In the greenhouse "potted plants"

The plants were almost always small and it was difficult to surround their twigs with celluloid cylinders.

3. — Eggs collected from adults living on the stock host plants were incubated in specimen tubes covered with muslin. The hatching nymphs were carefully shaken out of the tubes on to the leaves of the new hostplants, where they were left to migrate and settle. In spite of the fact that this method was also successful, yet it was difficult to control transference of known numbers of the nymphs, which was necessary for estimating quantitatively the success of the transfer.

4. — Leaves of stock host plants infested with the second stage nymphs were collected, and either left to dry up, or subjected to warmth produced by an electric bulb, and in both cases the nymphs were induced to withdraw their stylets from the plant tissues and started migration. It was then easy to lift the nymphs with a fime needle and release them on the new host plant without causing them any injury. It was also possible to transfer a known number of the nymphs, which facilitated the job of estimating the percentage of success. The only drawback, was that the nymphs, having previously fed on the stock host plant, had no chance of having a uniform diet throughout their lives. In any case, the change of diet after a short time of feeding on the old host, did not cause any appreciable difference from those which were transferred in the first stage and fed only on one type of food. This

Transferring experiments (1951-1952)

NEW HOST - PLANTS	STOCK HOST - PLANTS: Prunus persicae	Rubus fruticosus	Prunus cerasus	Cotoneaster microphylla	Pyracantha coccinea	Taxus baccata
Rubus fruticosus	(+ma.) + 34%	+ 46% + 30%		males + 73%	+ 30%	—
Prunus persicae	+ 40%	(+ ma.) + 56%	+ 27% + 20%			— —
Prunus cerasus			+ 40%			
Cotoneastermicrophylla				males + 80%		
Pyracentha coccinea					+ 40%	
Rosa spec.		+ 16%				
Ribes nigrum		— (+ ma.) + 20% + 30%		males + 40% + 50%		—
Ribes grossularia		— + 20% + 10%				—
Crataegus oxyacantha		+ 14%				
Betula alba	0	— 0 * + 50%		males + 80%		—
Robinia pseudoacacia		+ 3%		+ 3%		
Lonicera caprifolium				+ 7%		
Vitis vinifera		+ 10%				
Prunus domestica		+ 17%				
Fagus sylvatica		00 00 + 3%		males + 7% + 14%		— —
Taxus baccata	— —	— —	—	—	—	— + 14%

+ = transfer succeeded; — = transfer failed; * = transfer succeeded and plant died; 0 = transfer succeeded and insects died in the adult stage without oviposition; males = males were recorded; (+ ma.) = males succeeded in mating; (-ma.) = males failed in mating; % = percentage of success.

might suggest that the hibernation period being comparatively very long (about 8 months), nymphal feeding during this period is much less than the vigorous feeding of the insect during its young adult stage when it grows about twenty times its original size within a few days.

The first set of transferring experiments was carried out during the generation of 1951-1952. Six stock host plants were used, namely *Prunus persicae*, *Rubus fruticosus*, *Prunus cerasus*, *Cotoneaster microphylla*, *Pyracantha coccinea* and *Taxus baccata*. The insects were transferred from these host plants to sixteen new host plants, including control transfers to original host species. It is important to note here that the males of *L. corni* were recorded only on *Cotoneaster microphylla* which was used as one of the stock plants. Laboratory reared males were used for mating experiments with transferred females.

The results of these experiments are given in the above Table.

The following experiment was carried out by the end of April (25th) 1952. The male puparia on two twigs of *Cotoneaster microphylla* were destroyed in order to prevent uncontrolled fertilisation and only the females were left. They were all either in the young adult stage or in the second nymphal stage just before moulting to adults. These twigs were surrounded by celluloid cylinders in the same way used in the transferring experiments, so as to prevent any contamination from other twigs, and to prevent other males from mating with the females on these twigs. The cylinders were left on the twigs till the end of the next generation. The females started oviposition on the usual date (17.5.1952), and the hatching started on the 18, 6.1952. The progeny of these females were left on the same twig till the end of the 1953 generation, when they appeared to be all females, not a single male could be found on either of those twigs.

The following sets of experiments were also carried out for the 1952-1953 generation.

(*a*) A set of experiments in which the progeny of the females which had been previously transferred (1951-1952), were retransferred from the new host plants to the original host plants.

(*b*) A new set of transferring experiments was carried out, for the 1951-1952, with the addition of *Rosa* spec., *Robinia pseudoacacia* and *Ribes sanguineum*.

(*c*) The eggs of the females with which the males succeeded in mating in transferring experiments of the previous generation, were collected and separately incubated until hatched. The first stage nymphs were then transferred to a set of new host plants.

(*d*) Experiment (C) was repeated again as a control, with the eggs of unmated females collected from the same host plants.

The results of these experiments are shown in the following Tables (a-d), and the symbols used are the same as those used in the first Table for the 1951-1952 generation experiment.

(*a*) *Retransferring experiments*

STOCK HOST - PLANTS	NEW HOST - PLANTS: Priunus persicae	Rubus fruticosus	Prunus cerasus	Cotoneaster microphylla	Pyracantha coccinea	Toxus baccata
Rubus fruticosus	+ 40%	+ 50%		+ 65%	—	
	+ 30%				+ 15%	
Prunus persicae	+ 64%	+ 46%	+ 40%			
			+ 40%			
Prunus cerasus			+ 60%			
Cotoneaster microphylla				+ 64%		
Pyracantha coccinea					+ 14%	
Rosa spec.		+ 25%				
Ribes nigrum		+ 40%		+ 48%		
		+ 25%		+ 50%		
Ribes grossularia		+ 33%				
Crataegus oxyacantha		+ 7%				
Betula alba		—		+ 66%		
		+ 20%				
Robinia pseudoacacia		—		+ 2%		
		+ 4%				
Linocera caprifolium				+ 25%		
Vitis vinifera		+ 20%				
Prunus domestica		+ 7%				
Fagus sulvatica		—		+ 40%		
		+ 14%		+ 50%		
		+ 45%				
Taxus baccata						+ 10%
						+ 20%

DISCUSSION OF RESULTS

A brief account of the conclusions drawn from these experiments is given below.

1. — The success of transferring the different forms of *E. corni* from one plant to the other, and again re-transferring them to their original host plants. leads to the following conclusions :

(*a*) That *E. corni* is a potyphagous insect which is capable of feeding and adapting itself to several host plants.

(b) *Transferring experiments (1952-1953)*

NEW HOST-PLANTS	STOCK HOST-PLANTS: Rubus fruticosus	Prunus persicae	Cotoneaster microphylla	Prunus cerasus	Pyracantha coccinea	Rosa spec.	Robinia Pseudoacacia	Ribes Sanguineum	Taxus baccata
Rubus fruticosus	— + 7%	—	— +30% males	—	+ 3%	—		+ 3%	
Prunus persicae	+14% —		+14% males	*	+17%	+33%			
Cotoneaster microphylla	+30%		+10%						
Cotoneaster horizontalis	+ 3%		—					+14%	
Pyracantha coccinea	+ 7%		+ 7%						
Rosa spec.	— —	+14%	— —	+33%	+14%		—	—	
Ribes nigrum	+23%		—					+ 3%	
Ribes grossularia	+ 7%		—					+ 7%	
Crataegus oxyacantha	+10% 0	+14% —	+30% males	—		+14%			*
Betula alba	— —	+10%	— —	+14%	—	—			—
Robinia pseudoacacia	+ 7% —	—	+10%	—	—	—			
Ribes sanguineum	—	+60%	+80% males	+40%	*	—			
Linocera caprifolium	— + 7%	—	— —	*	+14%	—			
Vitis vinifera	—		+ 3%						
Cotoneaster lactea	—		+ 3%						
Prunus domestica	—		+70%				+ 3%		
Fagus sylvatica	* + 3%	—	— 0	—	—	—	—		—
Taxus baccata	— —		— —						+ 7%

STOCK HOST-PLANTS

(c) *Transferring experiments of progeny of mated females.*
(d) *Transferring experiments of progeny of unmated females "Control".*

		(c)			(d)		
		(1)	(2)	(3)	(1)	(2)	(3)
NEW HOST - PLANTS	*Rubus fruticosus*		+ 30%			+ 27%	
	Prunus persicae			+ 10% males (1)			+ 3%
	Cotoneaster horizontalis	—			+ 10%		
	Pyrocantha coccinea	+ 14% male (2)			+ 10%		
	Rosa spec.			+ 14%			+ 10%
	Ribes nigrum		+ 10%			+ 17%	
	Ribes grossularia		+ 10%			+ 13%	
	Robinia pseudoacacia			—			—
	Cotoneaster lactea	—			+ 3%		
	Prunus domestica		+ 4%			—	
	Taxus baccata	—		—	—		—

* Stock host-plants are represented under the following figures : (1) *Prunus persicae* transferred from *Rubus fruticosus*; (2) *Rubus fruticosus* transferred from *Prunus persicae*; (3) *Ribes nigrum* transferred from *Rubus fruticosus.*

(*b*) That these different forms are one and the same species with the same fundamental morphological structure.

(*c*) The different colours, sizes and shapes exhibited by the forms are mainly influenced by the host plant on which they live.

(*d*) The low percentages of success of transfer of insects to and from *Robinia pseudoacacia* seems to show that this plant may cause adaptation of the insects to a marked extent. This may be the reason that MARCHAL (1908) when meeting difficulty in re-transferring the insects from *Robinia* to the other host plants, named it as a distinct variety of *E. corni.*

2. — The failure of the transference of any of these forms to *Taxus baccata*, and the failure of the transference of *E. corni* var. *crudum* to any host plant other than *Taxus baccata* re-emphasises the fact that this variety is different from all the other forms, and should be raised to the rank of a species to which the writer gave the name of *E. taxi* nov.

3. — The percentage of success of the transferring experiments are markedly higher when using *Cotoneaster microphylla* as a stock plant, than when using other stock host plants. This suggests that the sexual progeny may be more viable than the parthenogenetic progeny.

4. — The occurrence of males of *E. corni* on new host plants to which the transfers were carried out from *Cotoneaster microphylla* shows that the males of this insect may live on other host plants. This has also proved to be true because of the occurrence of these males on some of the plants to which the progeny of the mated females were transferred.

5. — In spite of the fact that no fundamental structural differences could be detected between the males of *corni* and *taxi* other than the differences in size and colour, yet (*a*) the success of mating of males collected from *Cotoneaster microphylla* and reared in the laboratory, with the females of other forms on other host plants; (*b*) the failure of mating of males of *E. corni* with females of the form on *Taxus baccata*; and (*c*) the failure of the reciprocal mating. These facts again support the morphological conclusion that *E. taxi* is a different species.

6. — (*a*) The presence of males on some of the plants to which the progeny of the mated females were transferred; (*b*) the absence of males from the same host plants to which the progeny of the unmated females were transferred in the control experiments; and (*c*) The absence of males from the twigs of *Cotoneaster microphylla* on which the unmated females were isolated after the destruction of all the males.

These facts lead to the conclusion that mated females or in other words sexual reproduction gives rise to both males and females, while unmated females or parthenogentic reproduction gives rise to females only.

7. — All the forms had one generation a year, whether occurring on their natural stock plants or on the new host-plants to which they were transferred. This shows that the host plant has no effect on the number of generations of this insect.

8. — With regard to the *colour* of the adult females, it has always been noticed, that the colour of the naturally occurring forms on any host, was acquired by any other form when transferred to it. The change occurs from the first generation and no adaptation period was necessary as in the case of size and fecundity. There was no appreciable difference in colour between the insects which were transferred in their second nymphal stage in spite of the latter having previously fed for a comparatively short period on the original host plant. This, as already mentioned, may be due to the fact that the hibernating period is very long and feeding is rather slow during that period, while in the adult period feeding is extremely vigorous and causes rapid growth. It is this later feeding which almost completely accounts for the colouration of the insect in its final stage.

9. — With regard to the size of the insects, the dimensions of the transferred adult females were measured and their volume coefficients were estimated. These volume coefficients have then been compared with the volume coefficient of the forms naturally occurring on both the stock host plant and the plants to which they have been transferred.

The change in size towards that associated with the new host was gradual. In the first generation after transfer, the size attained by the transferred insects was

always intermediate between the sizes of the two naturally occurring forms. This show that a period of adaptation was necessary.

The following Table shows the averages of the original volume coefficients of the forms naturally occurring on both the stock and the new host plants which were used in the transferring experiments of 1951-1952 generation. It also shows the volume coefficient acquired by the transferred insects after their first generation on the new host.

Stock host-plants	Average volume coefficient	New host-plants	Average volume coefficient	New volume coefficient
Prunus persicae	34.8	*Rubus fruticosus*.....	23.3	28.1
Rubus fruticosus.....	23.3	*Prunus persicae*	34.8	31.1
Rubus fruticosus	23.3	*Rosa* spec.	50.8	40.4
Rubus fruticosus	23.3	*Ribes mgrum*	12.7	18.4
Rubus fruticosus	23.3	*Ribes grossularia*	15.3	21.9
Rubus fruticosus	23.3	*Crataegus oxyacantha* ..	30.4	25.8
Rubus fruticosus	23.3	*Betula alba*	10.1	12.9
Rubus fruticosus	23.3	*Robinia pseudoacacia* ...	64.5	54.0
Rubus fruticosus	23.3	*Vitis vinifera*	25.1	25.7
Rubus fruticosus	23.3	*Prunus domestica*	5.6	9.5
Rubus fruticosus	23.3	*Fagus sylvatica*	18.5	17.0
Prunus cerasus	32.0	*Prunus persicae*	34.8	32.1
Cotoneaster microphylla .	21.7	*Rubus fruticosus*	23.3	21.4
Cotoneaster microphylla .	21.7	*Ribes migrum*	12.7	15.7
Cotoneaster microphylla .	21.7	*Betula alba*	10.1	13.3
Cotoneaster microphylla .	21.7	*Robinia pseudoacacia* ..	64.5	59.3
Cotoneaster microphylla .	21.7	*Fagus sylvatica*	18.5	20.1
Pyracantha coccinea	15.5	*Rubus fruticosus*	23.3	19.2

The figures in this Table show that the new volume coefficient acquired by the transferred insects in nearly all the cases lies intermediate between the volume coefficient of both the stock and the new host plants, which shows that some adaptation period is required. The curve in Figure 14 shows the level of the new volume coefficient (54.0) acquired by the insects transferred from *Rubus fruticosus* to *Robinia pseudoacacia*. It also shows the original frequency distribution curves of the forms on both these two plants, whose average volume coefficients are 23.3 and 64.5 respectively. The frequency curve of the transferred insects could not be drawn owing to the low number of insects which transferred successfully.

Exceptions to this phenomenon might appear in some cases where the original volume coefficients of both the stock and new host plants are very close to each other, or in other words when their frequency distribution curves are extremely overlapping. The new volume coefficient acquired by the transferred insects in this case may not fall in between the original values as in cases of transfers from *Rubus fruticosus* to

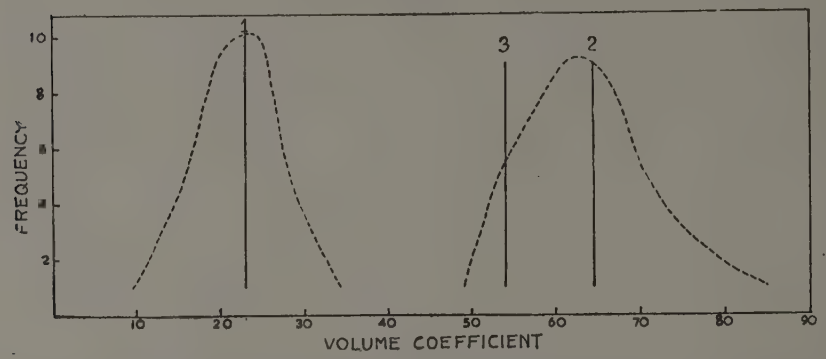

FIG. 14 : Frequency distribution curves of *E. corni* according to the volume coefficient (1) naturally occurring on *Rubus fruticosus* used as stock plant; (2) naturally occurring on *Robinia pseudoacacia* used as new host plant; (3) the mean volume coefficient aquired by the insects transferred from the former to the latter.

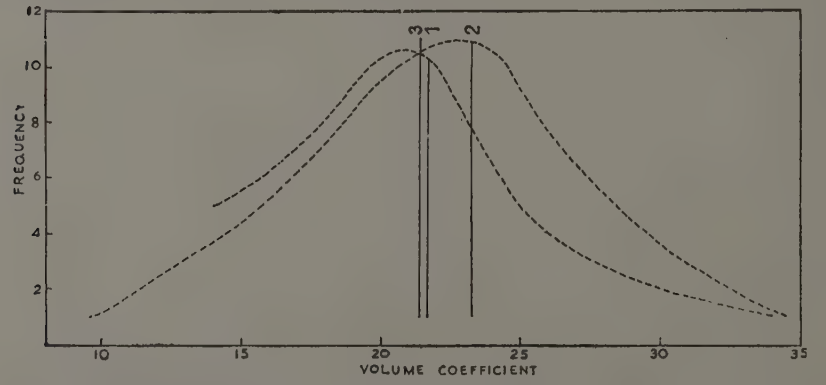

FIG. 15. Same as Figure 14, but (1) *Cotoneaster microphylla*, (2) *Rubus fruticosus*.

Vitis vinifera, from *Rubus fruticosus* to *Fagus sylvatica*, and from *Cotoneaster microphylla* to *Rubus fruticosus*. Figure 15 shows the overlapping frequency distribution curves of *Cotoneaster microphylla* and *Rubus fruticosus*, the average volume coefficients of which are 21.7 and 23.3, respectively, and shows also the value of the new volume coefficient (21.4) acquired by the insects transferred from the former to the latter host plant.

10. — With regard to the *fecundity* of the insects, the number of eggs laid by the transferred adult females was counted in some of the transferring experiments. The means of these numbers have then been compared with the means of numbers of eggs laid by the forms naturally occurring on both the stock host plant and the

plants to which they have been transferred. The figures are given in the following Table.

Stock host-plants	Mean number of eggs	New host-plants	Mean number of eggs	New mean
Prunus persicae	2394	*Rubus fruticosus*	1777	1652
Rubus fruticosus	1777	*Prunus persicae*	2394	2003
Prunus cerasus	1125	*Prunus persicae*	2394	1817
Cotoneaster microphylla .	1764	*Rubus fruticosus*	1777	1688
Pyracontha coccinea	208	*Rubus fruticosus*	1777	1024

The change of fecundity towards that associated with the new host is also gradual as in the case of size. The number of eggs laid by the transferred insects is always intermediate between the numbers laid by the two naturally occurring forms. This again shows that a period of adaptation is necessary.

SUMMARY

1. — Morphological observations showed that all of host forms of *E. corni* are identical in their structure except the form on Yew "*Taxus baccata*" which proved to be a distinct species "*E. taxi*".

2. — It is not safe to rely on the dimensions of the insect or on its volume in relating it to a certain host plant, a great deal of overalapping being present in both criteria.

3. — Six criteria were statistically analysed and consistently distinguished *taxi* from *corni* while failed to discriminate between different forms of the latter.

4. — Both the body size and fecundity of insects are independantly affected by the host plant. The effect on fecundity may be more marked on some plants than the variation of the body size.

5. — Transferring experiments showed the following : (*a*) re-emphasised the fact that *E. taxi* is a distinct species; (*b*) males of *E. corni* can develop on plants other than *Cotoneaster microphylla* on which they were recorded; (*c*) mated females or sexual reproduction gives rise to both males and females, while unmated females or parthenogenesis gives rise to females only ; (*d*) the host plant has no effect on the number of generations of this insect, all forms having one generation a year ; (*e*) the change of colour of transferred insects needs no adaptation period ; (*f*) the change in size and fecundity towards that associated with the new host plant is gradual and needs an adaptation period.

ACKNOWLEDGMENTS

The writer wishes to express his thanks to Professor J. W. Munro for offering all facilities throughout the work. Thanks are due to Dr. W. F. Jepson for his kind

supervision and constructive criticism. The writer is grateful to Dr. K. L. Boratynski for suggesting the work and for his consistent help. Thanks are also due to Dr. R.E. Blackith for his help in the statistical analysis of the results.

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THE LIFE-HISTORY, HABITS, AND CONTROL OF THE BERSIM GRASSHOPPER, *EUPREPOCNEMIS PLORANS* CHARP., IN EGYPT

[*Orthoptera* : *Acridiidae*]

(with 9 Text-Figures)

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INTRODUCTION

The most important economic species of grasshoppers in Egypt are *Euprepocnemis plorans plorans* Charpentier, *Aiolopus strepens* Latr., and *Thisoicetrus littoralis* Ramb.

In 1927, the farmers of El-Dakhla and El-Kharga Oases reported to the Ministry that great numbers of grasshoppers had invaded their fields and caused serious damage.

First control campaign was carried out in 1928 by using poisoned bait which contained Na_2 (As_2 O_3) at the rate of (3-5) % with molasses. The campaign continued till 1930 with satisfactory results.

In 1942, grasshoppers in great numbers invaded the fields of the Nile Delta, i.e. Lower Egypt; at least 95% of the damage to cultivated crops was caused by *Euprepocnemis plorans plorans* Charp.

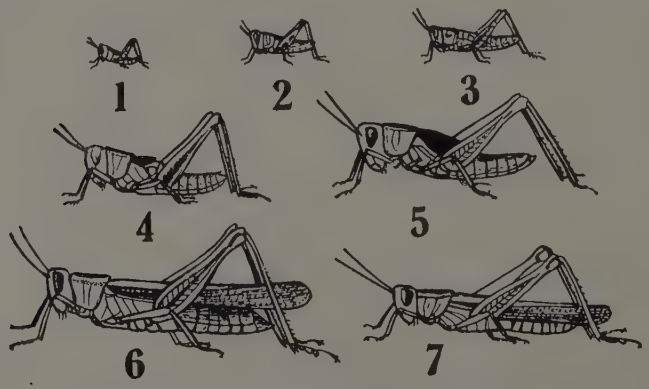
Organisations were made for compulsory control of grasshoppers in clover fields before harvest. The only method recommended for controlling this pest was the sodium arsenite bait at the rate of 2-3% on wheat bran basis, without molasses. The bait was effective under certain conditions, while in many cases the results were failure. The bad results obtained were due to many factors which will be discussed later.

Serious damage occured most frequentty in some villages of the following Provinces : Gharbiya, Foadia, Behera and Daqahlia. In other Provinces, even in Upper Egypt, few scattered individuals, together with different species of uneconomic importance, are found in fields and gardens.

The object of this contribution is to give a brief account of the life-history, habits, factors affecting grasshopper population and control measures of the *Euprepocnemis plorans plorans* Charp.

DESCRIPTION OF THE ADULT

General coloration pale brown with brown and grey markings. Head pale brown, with brown scattered spots on the face and clypeus, and with a narrow dark brown band along the anterior margin of the genae below the eyes. Antennae pale brown, invariably composed of twenty-six joints. Eyes dark brown, with six white longitudinal lines. Epicranium stramineous, with a pale brown median longitudinal band tapering at the apex between the eyes.



FIGS. 1-5 : The five nymphal instars of *Euprepocnemis plorans plorans* Charp. — FIG. 6 : Adult female. — FIG. 7 : Adult male. — All full size.

Pronotum light stramineous with a dark brown fusiform marking covering practically the whole of the disk and slightly narrowed behind. Fore and mid-legs stramineous; inner faces of femora of posterior legs light stramineous, outer faces light brown with black spots on knee lobes; posterior tibia bluish, becoming purple towards apices, with two whitish bands at the base and brown at the condyle, spines whitish with black tips.

Elytra smoky stramineous, with irregular brownish aerolets in the discoideal and apical areas, and with a sulphurous axillar stripe. Wings hyaline.

Abdomen pale brown with light greyish markings, conical, straight, compressed, the last dorsal segment of the male of ordinary shape, its anal plate triangularly

wrinkled at the base. Male cerci long, dilated at the base, and curved at their apical part; in the female they are short, triangular, and obtuse. Sub-genital plate conical, straight, obtuse, and passing beyond the cerci in the male; large, with the posterior side pointed at the middle in the female. Valves of the ovipositor long, inner valves serrated in the outer side (Fig. 9).

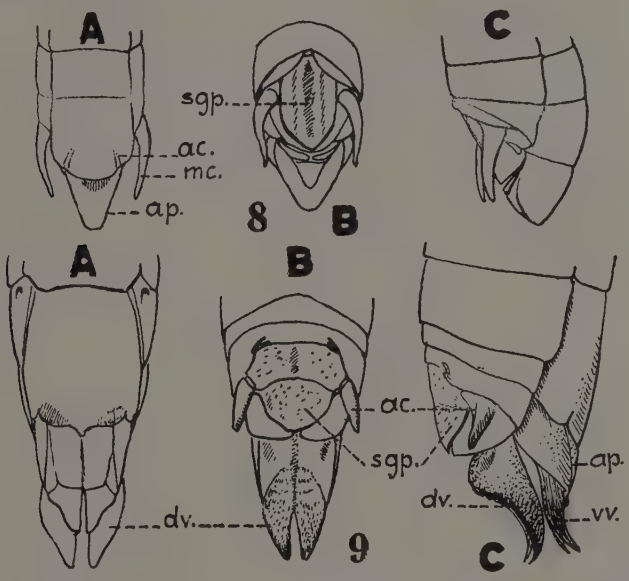


FIG. 8 : Posterior abdominal segments of the adult male of *Euprepocnemis plorans* Charp, (A. ventral, B. dorsal, and C. lateral view; ac., anal cerci; ap., anal plate; mc., male cerci; sgp., sub genital plate). — FIG. 9 : Posterior abdominal segments of the adult female of *Euprepocnemis plorans plorans* Charp. (A. ventral, B. dorsal, and C. lateral view; ac., anal cerci; ap., anal plate; dv., dorsal valves; sgp., subgenital plate; vv., ventral valves).

Dimensions (average of 20 samples, from breeding cages) : length 35 mm. (male), 39.5 mm. (female); pronotum 5.5 mm. (male), 7.5 mm. (female); elytra 27 mm. (male), 30 mm. (female); hind femora 15.5 mm. (male), 22.5 mm. (female).

GEOGRAPHICAL DISTRIBUTION

The distribution of *Euprepocnemis plorans* in Egypt has been given in the introduction. This species also occurs in Iran, Algeria, Tunisie, Syria, Macedonia, Palestine, Transcaucasia, Abyssinia, Spain, Sicily and Japan, as reported by A. FINOT.

LIFE-HISTORY

Under field conditions

Observations made in the field during the years 1942-1945 can be summarised as follows :

Egg-laying occurs from July to November; the majority of egg-masses laid in late summer and autumn pass the winter in the egg-stage and the young hoppers hatch out during the ensuing spring.

The nymphs reach the adult stage after undergoing six moults. Oviposition is general during August and September. The adults begin to dwindle in number in the second half of October, but there are still numerous egg-masses in the soil during winter. Only a very insignificant percentage of the eggs laid in early summer hatch out in summer. Thus, the insect has one main generation under field conditions, of which the hoppers appear in great numbers during late spring and early summer. Small scale hatching which may occur during early spring, produces part of a second generation, which reaches the adult stage, mature and lay eggs in June. These egg-pods hatch out during July and give rise to sexual mature individuals, which oviposit in autumn. Such eggs hibernate until next spring.

Under laboratory conditions

Females are ready for copulation after reaching the adult stage, while males start copulation after one to two weeks from the last moult. The process lasts for about 1 to 4 hours, sometimes six hours, and rarely a whole day. Males and females copulate several times, sometime as many as twenty times within 25-30 days, and both polyandry and polygamy are quite common. There is frequent copulation both before and after oviposition.

The pre-oviposition period in the virgin females varies from 29 to 63 days, with an average of 32 days from the last moult (average of one hundred cases). The period intervening between the first copulation and the first egg-laying varies from 20 to 30 days, although in some cases the period may be one week only according to the maturity of the ovaries.

The eggs are laid in the soil, about 1.25-1.50 inch below the surface. In the process of egg-laying, the female thrusts her abdomen into the ground and searches for a suitable spot by scratching the surface of the soil with its ovipositor. The formation of the hole takes from half to one hour. The length of the egg-mass is about 2.5 cms. and the emergence tube measures 3.5 cms. The abdomen of the female measures between 1.7 to 2.1 cms. in length in the normal position, but it can be extended twice the length with the help of the elastic inter-segmental membranes. In many cases, the female makes several holes and discards them without laying any eggs, probably because of the unsuitable texture or moisture content of the soil. Before depositing her eggs the female emits a brown foamy secretion into the hole and the eggs are passed into this secretion. The female gradually retracts its abdomen

as the hole gets filled up with eggs. When all the eggs have been laid the vacant space in the hole is filled with foam up to the top. The whole process lasts from one to three hours.

The number of egg-pods produced by a single female varies from two to four, more frequently three. The number of eggs in the egg-pod varies between 30 to 50, the average being about forty.

The duration of the incubation period varies and depends chiefly upon temperature and season, kind of soil and amount of moisture content. The egg-masses laid in early summer hatch out after an average of three weeks, while the egg-masses laid in late summer and autumn hatch out after 4.5 to 5 months.

There are six moults, the average period between them in summer being as follows : first instar, 10-12 days; second instar, 8-9 days; third instar, 9-10 days; fourth instar, 9-10 days; fifth instar, 10-11 days; sixth instar, 11-12 days. The total nymphal period varies from 56 to 63 days.

Leaving out of consideration such examples in which the male or female died prematurely before copulation or oviposition, observations have shown that the length of the life of the adults varied from 3.5 to 5.5 months with an average of about 4.5 months. Under field conditions very few scattered individuals were seen alive till month of February, a period of about six months from their reaching the adult stage. It was noticed also, that the females remained alive for a longer period than the males.

In the breeding cages and under favourable climatic conditions, the number of generations varies from two to three yearly.

The soil used for egg-laying was sandy and moistured at regular periods, contrary to what happened in nature. The following two examples show clearly the number of annual generations in the laboratory.

	Stages	Dates 1940-1941	Dates 1942-1944
F_1	Oviposition	10. 5.1940	28. 6.1942
	Hatching	28. 5.1940	14. 7.1942
	Adult	13. 7.1940	12. 9.1942
F_2	Oviposition	6. 8.1940	20.10.1942
	Hatching	3. 8.1940	16. 3.1943
	Adult	20.10.1940	29. 5.1943
F_3	Oviposition	26.11.1940	15. 7.1943
	Hatching	29. 3.1941	11. 8.1943
	Adult	29. 5.1941	5.10.1943
F_4	Oviposition		12.11.1943
	Hatching		23. 2.1944
	Adult		3. 5.1944

The insect in the first example, produced approximately three generations during one year; while it produced in the second example, four generations during two years, i.e. two generations yearly.

BEHAVIOUR

There is a relationship between environmental conditions on different stages of activity in the family Acrididae. Weather conditions, type of soil and vegetation play an important role in the development and activity of grasshoppers. The most important factor controlling the daily behaviour is temperature.

Other factors controlling the behaviour are : light, rain, wind, relative humidity, and mechanical stimuli.

In some partitions of the big cage

The following observations were made in small breeding cages and in some partitions of the big breeding cage at Dokki, at half hour intervals from 6 a.m. to 6 p.m. from June to September, during the years 1942-1944. These observations show at what temperatures the majority of grasshoppers respond to the different factors from the hatching to the adult stage.

After leaving their embryonic membranes the newly born nymphs lie motionless facing the sun till their bodies became dry; the time varies from few minutes to half an hour. The hoppers did not feed after hatching for a period which varied from six hours to one day and rarely extended beyond that (observations in small breeding cages).

On one sunny day (temperature 19°C.) the hoppers dispersed soon after sunrise, dropping off the plants on which they spent the night. At first, they enjoyed the warmth of the sun, then they began to move (temperature of the air 20°C., surface soil temperature 21-22°C.). The first day feeding took place with air temperature between 19 and 22 °C. The hoppers fed upon green and dry leaves of whatever plants they met in their way. They climbed on the stem of plants at temperature between 22 to 25 °C., jumping from one place to another when disturbed, and they still fed till the temperature of the air reached about 28°C. With the air temperature between 35 and 36 °C., the small hoppers dropped off the plants and took refuge under them. In more advanced stages (4th and 5th instars, and adults), feeding took place at high temperatures between 32 and 33 °C. Here, the adults fed voraciously upon maize leaves an husks (the partitions of the big breeding cage were cultivated with maize, cotton and rice). Thus, feeding took place at temperatures between 20 and 32 °C., the optimum temperatures being between 22 and 27 °C.

Less activity was shown on cloudy days : hoppers became motionless in their refuge under plants, as long as the sky remained cloudy, and this occurred also on rainy days.

The majority of adults copulated at temperatures between 28 and 32 °C. The process took place on the plants and rarely on the ground.

As regards egg-laying, observations made in some partitions of the big cage can be summarised in the following :

The most preferable spots for oviposition were those near the walls of the breeding partitions and on the ridges of plots. Different modes of cultivation were followed in four plots of a partition, mainly dense cultivation of clover, loose cultivation of maize, and cotton with maize on ridges. The loosely cultivated plots were prefered for oviposition. Few females laid their eggs in the other two plots at the bottom of the ridges and others oviposited on beds separating the plots. Thus, the most prefered spots for egg-laying were bare ground and uncultivated spaces between plants.

Fliers spent most of the day on high plants (maize and *Melia azadirachta* or hanged on the wire surrounding the partition. They rarely descended to the ground. Between 35 and 38 °C., they stood motionless on maize leaves, also between the stems and leaves or husks.

Under field conditions

Concentration of egg-laying depends upon degree of infestation (population) and the environmental conditions in the infested fields. The majority of grasshoppers live in very loose associations, lay their eggs in separate places in road-tracks, canal banks, fallow land and inside the clover cotton fields and in ridge banks of rice fields. The minority live in dense associations, lay their eggs together in the barren land filled with thorny grasses. This case was noticed in Disuq (Foadia Province) during August, 1942.

Hoppers invaded the clover fields in great numbers from bare lands after other winter crops and fallow lands neighbouring the clover when it reached the ripening stage. These nymphs acquired the colour (imitative coloration) of dry clover after undergoing one or two moults (Sakha farm 1943, 1944 and 1945). Also this phenomenon was more distinct among hoppers reared in wheat fields in which the nymphs acquired the yellow golden coloration.

In May 1945, observations made in Sakha farm showed that in green clover fields there were few scattered hoppers, while in the ripening field the insects increased in number due to their aggregation in the drying patches. Also, this phenomenon was quite distinct in a green clover field in which there was about half an acre of dry clover plants (the dryness was due to the effect of the parastitic *Cuscutta* spec. plant. The hoppers congregated in great numbers in the dry portion, while very few individuals were scattered in the green part of the field (second, third, and fourth instars).

Hoppers living on bare ground after winter crops such as barley, beans, etc., fed upon herbs, e.g. *Alhagi maurorum*, *Sonchus oleraceus*, *Brassica bracteolata*, etc., and even dry weeds were favourable to the insects. With a rise in temperature they took refuge in the soil cracks and under wild herbs.

When the bare grounds were irrigated before cultivation of maize or other crops, the hoppers of more advanced instars shifted to the ripening clover fields. The occurence of some early instars in clover fields was due to their hatching in the same field (first and second instars).

After cutting the clover, the hoppers of more advanced instars and fliers congregated numerously on clover heaps in the field. Few numbers were scattering in bare land and near road-tracks and canal banks. On removing the clover heaps, the insects invaded the neighbouring fields such as maize, rice and cotton.

When fliers reached sexual maturity (July and August), copulation took place on plants and rarely on the surface of the ground. Egg-laying in great numbers took place during August and September in places stated above. In the second half of October, the adults began to dwindle in number after laying numerous egg-masses in the soil.

FOOD PLANTS AND NATURE OF DAMAGE

Euprepocnemis plorans, as its popular name "Berseem grasshopper" indicates, is very found of Egyptian clover (*Trifolium alexandrinum*) on which it feeds upon every part (leaves, stems and florescences). The invaded clover fields give a small yield of seeds according to the degree of infestation.

In maize, hoppers devour the whole of the seedling, while in the growing plants hoppers and fliers feeds voraciously upon the leaves, pollen grains, leaves covering the husk, kernels and tips of cobs. As a result, pollination is incomplete and the cobs contain only few scattered seeds.

In leguminous crops and vegetables, hoppers feed moderately upon leaves, stems and green fruits. Cotton is only infested by grasshoppers after the formation of flowers and young bolls. The insects feed upon leaves, cortex of the stem, the new succulent branches, and gnaw the fruit-bearing branchlets bearing the bolls, causing their fall from the shrubs. Hoppers feed slightly upon cereals.

Food plants may be arranged according to their preferability as follows : Egyptian clover, maize (mostly prefered), leguminous crops, vegetables (moderately prefered), cotton, cereals, sugar cane (less prefered), lupines, flax, lucerne (untouched).

FACTORS AFFECTING THE GRASSHOPPER POPULATION

Observations made under laboratory and field conditions can be summarised in the following :

The most important factors affecting the population of the grasshoppers are : weather conditions, kind of vegetation (crops), land reclamation and natural enemies.

1. Weather conditions

The state of weather conditions affects the newly born grasshoppers. Dry and warm weather are most suitable for their development and increase. High temp-

erature and relative humidity were unfavourable factors, especially in their first nymphal instars. High percentage of the first instars died within ten days and before they reached the second instar, as shown in the following Table.

Effect of weather conditions on 640 first instar newly born nymphs hatched on 3rd May 1943 and kept in a cage measuring 70 x 70 cms.

Number of nymphs died before reaching second instar	Date of death	Temperature in °F		% Relative humidity	
		Minimum	Maximum	Minimum	Maximum
70	4.5.1943	66	95	63	75
66	5.5.1943	70	97	62	74
87	6.5.1943	75	99	60	78
93	7.5.1943	75	103	59	76
72	8.5.1943	78	103	60	70
43	9.5.1943	80	98	64	67
27	10 to 14.5.1943	66	90	63	78
485					

Thus, 71.5% of the nymphs died before they reached the second instar, and only 3.1% reached the adult stage.

2. Kind of vegetation

It was observed that the increase of grasshopper population always followed an increase in the area cultivated with rice; i.e. whenever there is enlargement in semi-aquatic crops, a rise in the numbers of grasshoppers is expected in the following years. This is due to the fact that the margins of rice fields present favourable sites for egg-laying.

The 1942 invasion took place in the Nile Delta after the tendency for increased grain production (including rice) during the preceding two years, as a war necessity. Since then, observations confirmed this correlation between areas cultivated with rice and grasshopper population.

3. The expansion in reclaimed lands

During the last half century, there were many individual and collaborative projects towards changing the salty soils and swamps of the northern Delta to productive soils of annual crops. This change offered another suitable abode for the development of the grasshopper which thus found a wider area for its multiplication. The regularity of irrigation, drainage, and the cultivation of forage crops in these reformed lands provided an ideal environment for grasshopper reproduction.

4. Fungi diseases and parasites

In the previous years, the death of many adults, some separately and others copulating, was observed. On examining dead grasshroppers, it was found that

death was due to a fungus disease. It was observed, too, in the breeding cages, that several by samples collected from infested fields were parasitized by larvae belonging to the Tachinidae (Diptera). Several kinds of parasitic flies were seen depositing maggots upon *Euprepocnemis* in their mature or nearly mature stage. These endo-parasitic maggots devours the internal portions of the grasshopper body and soon causes its death. Several kinds of digger wasps also kill or stupefy grasshoppers by stinging and then dragging them into their underground nests. Birds also play an important part in the natural control.

METHODS OF CONTROL

1. Destruction of eggs

Many authorities recommend ploughing, disking or harrowing for the destruction of eggs. The main object in these operations is to expose the eggs to the sun or other natural enemies, instead of being buried far in the soil.

In regarding the places in which the *Euprepocnemis* lays its eggs as stated before, this method is of limited use as it does not prevent hatching. Besides, it is uneconomic and impractical.

2. Destruction of nymphs and fliers

A. Poisoned baits

Poisoned baits are still regarded as the easiest, most economic and efficient method for grasshopper control. The problems with bait are : (1) cheap carriers; (2) a poison with high toxicity to the insect, and having a long residual period and little hazard to man, farm animals and vegetation; (3) a substance that would increase the attractiveness of the mixture, if possible.

1. — Wheat bran is the carrier most commonly used according to the following formula : 100 lbs. of wheat bran and 2-3 lbs. of BHC (containing 2.6% gamma isomer) and 150 litres of water.

If other carriers are to be used, the quantity of insecticide should be increased with increased volume of material.

The quantity of water to be added to different carriers depends upon (a) the fineness of particles : it is desirable that carriers should rather be coarse to reduce the tendency of forming lumps; (b) moisture contents of the carriers; and (c) capacity of absorbing water.

Other materials that have been used successfully to replace all or part of the wheat bran were : ground skin of wheat grains, crushed maize cobs, saw-dust and coarse rice refuse. Some of these products are cheaper in price and more available. They are used at the following proportions :

Material	Unitary volume in cms	Weight in grams	Ratio beetween carrier and water	Percentage BHC
Wheat bran	250	85	1:1.5	2
Ground skin of wheat grains	250	32	1:2.5	4
Coarse rice refuse	250	72	1:1	3
Crushed maize cobs	250	72	1:2	3
Saw dust + wheat bran ratio 1:1 by volume	250	68	1:1	3

The amount required per acre varies according to the volume of material used, the degree of plant growth and the nature of the treated area. When using wheat bran in the poison bait, 20-25 kgs. of the dry weight is sufficient for application, while in ground wheat skins 10-15 kgs. are sufficient. When using the other carriers, a quantity varying from 15 to 20 kgs. is applied (treatment among low vegetation).

2. — The toxicants tested in baits were sodium arsenite, sodium fluosilicate, barium chloride, D.D.T., BHC, and Aldrin. The sodium arsenite bait was always used as a standard treatment in each experiment together with an untreated cage as control.

Experiments carried out with the above insecticides can be summarised as follows :

The mortalities obtained by using sodium arsenite (80% active ingredient) at the rate of 0.5% on wheat bran basis were quite satisfactory against the first nymphal instars. The percentage mortality obtained by using 1-2% did not differ in the final results. A high rate content up to 3% of AS_2O_3 was found to be repellent to the first instars of *Euprepocnemis*. The ratio 1-2% of AS_2O_3 was recommended for controlling grasshoppers in all instars.

Sodium fluosilicate was a more rapid killing agent when used at the rate of 4%, but did not exceed sodium arsenite.

Barium chloride was particularly effective when newly prepared, while old samples proved to be less toxic. The rate of application was 2% for the first nymphal instars, and 4% for more advanced instars.

The compounds of D.D.T. used were Pest-master (50% D.D.T.) and Geigy 33 (10% D.D.T.) and the results obtained were unsatisfactory. The rate of application was 2-5%.

Benzene hexachloride was found to be a quicker killing agent than sodium arsenite; but the final results were equal. The product used contained 20% of crude benzene hexachloride $C_6 H_6 CL_6$ mixed with 80% of gypsum. The ratios for application were 2-3% and the same ratios of sodium arsenite were used for comparison.

Observations showed that the BHC bait acted as a contact poison on the first nymphal instars (first to third instar), for some of them died within half an hour (and before) eating the fatal dose; as a result of crawling over the baited area.

Also, the benzene hexachloride proved to be far less toxic to animals, for this reason and because of its high toxicity to the insects, it is recommended to replace the arsenical compounds.

Preliminary tests upon some emulsifiable insecticides, i.e. Acrodel (11% gamma isomer), Hexamul (12% gamma isomer and Aldrin 60 (60% hexachloro-hexahydro dimethano naphthaline) gave satisfactory results when used at the rate of (0,5 to 1% for BHC compounds on wheat bran basis against the different nymphal instars and adults of *Euprepocnemis*; while only 0.2-0.5% of Aldrin 60 was quite effective. Investigations concerning the toxicity of these materials to insects and livestock and their residual effect are still going on and any results achieved will be published in due time.

3. — It is now known that molasses does not increase the attractiveness of bait, the wet bran in itself being an attractant. Morill (1918), mentioned that no appreciable difference was observed between a series of baits with molasses and a similar series without molasses. Experiments carried out in Egypt have proved conclusively this result. It has also proved that fermentation does not affect the attractiveness of bait.

Can water be considered as an attractant agent in the poisoned bait ?

Many authorities mentioned that moisture is an important factor in the attractiveness to the hoppers and that dry baits seem unattractive. Experiments carried out in some partitions of the huge cage and in breeding-cages may be briefly summarised as follows :

1. — There was no significant difference in the final results of mortality obtained in a series of dry baits and a similar series of wet baits. The poison used was fine barium fluosilicate at the rate of 4% on wheat bran basis and the insects were in the 5th and 6th instars.

2. — The wet bait became dry after the elapse of 2-6 hours according to weather conditions, its soft particles became hard. In this case hoppers of the first nymphal instars found it hard as a food, while the more advanced instars fed sparingly upon it (experiments on pan-baits). Also, hoppers and fliers fed upon dry leaves and dry clover together with green vegetation.

3. — Apart from the above evidence, it was observed that hoppers and fliers kept themselves upon maize plants and rarely descended to the ground; both wet or dry bait did not attract the insects when applied in the late morning. Thus, hoppers fed upon bait if they happened to walk over it, and not for its attractiveness. For this reason, baiting should be carried out when the insects are at least active, and when the majority of hoppers are on the surface of the ground, in order to increase the chances of their remaining on the baited area for a longer time. So, the importance of adding water is to dissolve the particles of the crude poison if soluble in water, or to make the poison in a suspensed condition if insoluble, so that the poison may be distributed equally among the particles of the carrier. Adding water, also, renders the spreading of bait in the infested fields easier, and makes the bait remain

longer on the ground. It, also, retards the tendency in a dry bait to form heaps during a strong wind. Later experiments showed that in high temperature the insects fed more voraciously upon wet baits than on dry baits.

Baiting technique

It is of the utmost importance that the person or persons responsible for the process should give great care to when and where the poisoned bait must be used. The best time for control is when the hoppers are in their early nymphal instars and before getting a chance to spread over a larger area. Another point of equal importance is where to carry out the control process. Both points may be considered as essential for attaining success. To clear this point, we have to assume that an area is left bare after a winter crop and surrounded by cultivations of rice, clover, cotton and vegetables, respectively. If control is carried in the bare land in the early spring (May), we will prevent the movement of insects to the other cultivations. Hence, more than threefold the quantity of bait and time for control are saved, a case which would be inevitable if control is retarded to later months.

In cases of infested clover fields, it is advisable to carry out the control immediately after cutting and not when the plants are standing in the field.

Regarding time of the day when the bait should be scattered, no precise hour could be given because this is dependable on the temperature which the majority of the nymphs find on the surface of the ground. Anyway, the most suitable time for this process is before sunrise; reference to this is stated in the behaviour of the insect.

Experiments to determine the best method of distributing the bait were carried out. Treatments followed were by scattering (*a*) in lines, (*b*) the whole area thinly, and (*c*) separate spoonfuls. The second method proved to be the most successful and more economic.

It was found that the quantity of bait per feddan for control among high plants was 30-35 kgs. of dry bran, and 20-25 kgs. among low plants and on bare ground. It the destruction of hoppers is not thorough after the first application, a second treatment should follow.

To ascertain the result of baiting, the treated area must be examined after two or three days.

Repetition of baiting is also necessary on bare grounds where breeding takes place, because hatching occurs at intervals and newly hatched hoppers may emerge after the first treatment. The second application should be carried out after the elapse of two weeks from the first one

It must be stated that baiting does not completely exterminate the insects, but is considered successful when about 75-85% of hoppers are killed. The aim of using bait is to minimise the number of insects as far as possible, year after year, to prevent damage caused by dense populations in the future.

It was found that under the following conditions the poisoned bait gave unsatisfactory results.

1. — In the dry clover fields when hatching occured late in June, the young insects were found on the edges of the dry plants and rarely descended to the ground.

2. — When the insects remained on high plants as in ripening maize fields with insects in the adult stage, grasshoppers were found hanging on the top of the plants. Even in high temperatures they took refuge under leaves or between leaves and husks.

3. — Also, in the rice fields, it was not practical to use baits because the fields were usually inundated with water. In case of using baits around the margins of the rice field, it was noticed that the majority of the insects remained over the rice plants inside the field and they rarely moved to the margins.

4. — In very dense vegetations, the bait was lost umong the leaves and in dry lands containing large cracks, it was lost in these cracks.

B. Dusting and spraying

Although the poisoned bait is considered the standard method for controlling grasshoppers in Egypt, yet, under certain conditions, it is advisible to use dusting. Up till now baiting is cheaper and easier than both dusting and spraying. Because of the high cost of spraying, it is not adopted for grasshopper control.

In the cases when baiting have bad results, dusting is recommended. Also, it is of utmost importance that dusting can be carried out at any time of the day, contrary to baiting which ought to be applied in the morning before the insects start their activities.

The insecticides used in dusting were : Agrocide 7 (2.6% gamma), Solvexane 5 (0.65% gamma), Octaklor (50%), Toxaphene (40% chlorinated camphene) and chlordane (25% sulphide of BHC). From all these insecticides, the Agrocide 7 proved to be the most effective. This material was diluted with rock phosphate (which is available at low prices) at the rate of 1-2%, i.e. the final mixture contains 0.866 gamma. It proved to be harmless to vegetation except in rice fields where it caused the withering of leaf edges, but this case was temporary and the plants resisted this bad effect and thrived.

BHC dusts proved effective and a dust of 20% BHC diluted at the above rate gave complete kill within 24 hours. Paralysis started half an hour after the operation was finished. It was noticed that adults were more sensitive to BHC compounds than 4th and 5th instar hoppers. In some experiments under field conditions, the dusts had a residual effect which continued up to 15 days from treatment.

Hand dusters were used for limited areas and motor dusters for larger areas, but these machines need some alterations to be suitable for grasshopper control under local conditions. Two hand dusters by two labourers dusted one feddan in two hours, with motor dusters from 15-20 feddans were dusted in the same time;

when climatic conditions were favourable, usually hand dusters gave better results as the materials reached the insects in sufficient quantities.

There are some difficulties which are met with when using motor dusters.

1. — Direction and velocity of wind interfere to a great extent in the success of the operation. Sometimes high winds carry the dusts astray from the field or in other directions and do not allow the dust to reach the target in sufficient quantities.

2. — The hose of the duster is fixed and dusts only in one direction perpendicular to the line of the machine march, this makes the dust not homogenous in all the field.

3. — The high sound caused by the motor disturbs the adults causing them to fly in directions away from the drift.

4. — The machine needs a wide road and this is not always available.

SUMMARY AND CONCLUSION

The control of the grasshopper *Euprepocnemis* would be an easy task if carried out in the proper time and place, and by adopting a method which is effective according to the daily behaviour of the insect.

Behaviour under field conditions

1. — The insects, which are usually found in loose aggregations, lay their egg-pods separately in the slopes of ridges, canals and drains.

2. — Hatching occurs in winter crops such as berseem, barley, beans and wheat. The newly emerged hoppers are small in size, about 5-6 mm. long and fawn coloured. These hoppers live and feed on these crops until they reach the 4th. or 5th. instar.

3. — By June, these crops are harvested and most of the hoppers move to clover fields. It was always observed that the number of insects in maturing clover was higher than in green clover. The remaining hoppers remain in the unproperly harvested fields where weeds grow, or, move to the neighbouring weedy drains.

4. — At the time of clover harvest, the majority of the grasshoppers become fliers and can move to relatively longer distances, so the insects become distributed in the different summer crops such as cotton, rice, maize, vegatables, etc.

As the area cultivated with clover is relatively small when compared with summer crops, so the insects get dispersed on a wider scale after the harvest of clover. Moreover, the insect in this stage is voracious and devours maize seedlings which thus needs resowing. On the older maize plants, grasshoppers feed on the blades of leaves, pollen grains (which prevent pollination and fertilization), on cobs, ears and cob-covers, thus producing a noticeable loss in the crop. They also cause some damage to other summer crops.

Forage crops are affected to a great extent with grasshoppers, and they congregate in great numbers on weedy margins and under heaped hay.

5. — Hatching does not occur at one time, but at intervals and it is general from mid-May to mid-June, and in the northern localities hatching continues up to July.

Control

1. — Until now baiting is considered to be the basic method in grasshopper control. The constituents of the bait are wheat poisoned with any benzene hexachloride compound. The BHC compound usually used is that containing 20% of the four isomers and is used at the rate of 2-3% with the bran. The compound is added to the bran and mixed dry, then water is added gradually at the rate of 1.5 part water to one part bran.

However, it must be known that dusting will be the standard method for grasshopper control in the near future. It must be taken in consideration that the longest period of the insect's life is the *adult stage*, and that in this stage the insect becomes very active and that its stay on the baited area is very limited. Also, it causes serious damages in this stage. To obtain rapid and satisfactory results, *dusting* must be used. Sooner or later the dusting method will replace the baiting one in use for controlling grasshoppers.

2. — It must be understood that the insects feed on the bait only when it comes in their way, when they descend to the ground, and this happens in lands with low vegetations.

3. — Arsenic compounds must not be used as they are hazardous to man and animals.

4. — Control should be limited to areas containing from 5 to 10 grasshoppers per square metre. Anybody responsible for control should be aware of the following :

(*a*) Thoroughly watching early winter crops, and controlling the young hoppers before they reach advanced stages or move to clover fields. The fields should be irrigated before baiting, so that the bait would not be lost in the crevices.

(*b*) In clover, it is better to carry out the control after mowing. In cases where there is late hatching in ripening clover, control is carried after the harvest and the bait should be broadcast around hay heaps and around drains and canals.

If hoppers exist in early winter crops, they normally move to clover fields where nymphs breed. Consequently, the hopper population increases in clover. So, it is essential to carry out control in clover fields before the insects move to a larger area in summer crops.

(*c*) If the population is high in field margins, around drains and canals, the bait is broadcast (not too thinly) in lines along these places. This applies also to cotton fields.

(*d*) In fields where maize plants are low, the bait is scattered in the whole area; but when maize is tall, it is advisable to put some bundles of hay as a trap around the field and then scatter the bait around them.

(*e*) In dry bare lands after winter crops, and when no irrigation is possible, it is better to leave the crop heaped for some days in the field and scatter the bait around the heaps and along the margins and drains.

(*f*) Baiting should be carried out only in the early morning before the insects begin their activity or before sun set with regarding the favourable climatic conditions in using the bait before sun set. The quantity of bait per on feddan when broadcast in the whole area varies from 20 to 25 kgs.

(*g*) Dusting is recommended in cases where baiting gives bad results, but dusts must reach the body of the insects. The dose per feddan varies according to the treated area (bare, loosely or densely cultivated) and to the machine used (motor or hand duster); then the quantity varies from 25 to 40 kgs. when using hand dusters, and from 15 to 20 kgs. when using motor dusters. The determining factors for using motor or hand dusters depend on the circumstances in the field itself (suitable roads, area, etc.) and on weather conditions.

ACKNOWLEDGMENTS

I am greatly indebted to the authors of the papers listed in the bibliography for facts incorporated with this problem. My deepest gratitude is due to Messrs. Mohamed Soliman El-Zoheiry and Ibrahim Bishara, the former and present Directors General of the Plant Protection Department, respectively; to Messrs. Mohamed Hussein, the former Chief of the Locust and Grasshopper Researches, and Antoun Cassab, the Assistant-Director of the Entomological section of the Ministry of Agriculture, for their valuable advice and guidance during the course of my investigations. Sincere thanks are also due to my colleague Mr. Mohamed El Sayed Hassanein, and to the artists who produced the drawings illustrating this paper.

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THE MOUTH PARTS OF THE LARVAL INSTARS OF *PSOROPHORA CILIATA* (FABRICIUS)

[*Diptera ; Culicidae*]

(with 39 Text - Figures)

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CONTENTS

I. Introduction. — II. The mouth parts of the fourth instar larva. — III. The mouth parts of the third instar larva. — IV. The mouth parts of the second instar larva. — V. The mouth parts of the first instar larva. — VI. Summary of the important instar differences. — VII. Key to the larva instars of *Psorophora ciliata* based on the head structures. — VIII. Acknowledgments. — IX. Selected references.

I. INTRODUCTION

The larvae of *Psorphora ciliata* are of unusual interest because they are of the few whose larvae are predators on other mosquito larvae. They are usually found in nature in association with large numbers of *Aedes vexans* (Meigen) and with other species of *Psorophora*. It is of interest to note that the first instar larvae of this species are not predators. They feed by filtering the food particles from the water by the aid of their labral brushes. After the first moult, individual rearing is recommended because of the predacious habits of the second, third and fourth instars; thus avoiding the possibility of them feeding on each other. When hungry the predacious larva suddenly attacks one of the nearby smaller larvae, grab it with its strong mandibles and prevent it from escaping with the help of the labral brushes. It gradually manoeuvres it, so it can be swallowed. It seldom swallows the head of its victim. One fourth instar larva usually consumes four on five *Aedes* larvae per day. Considerable mortality occurs among the predacious larvae, while rearing in the laboratory.

The head capsule in all the instars, is prognathus. The head and the mouth parts of the fourth, third and second instar larvae, are adapted to the predacious method of feeding. However, the head and the mouth parts of the first instar larvae are adapted for the filtering feeding method similar to those of *Anopheles quadrimaculatus*, *Aedes aegypti*, and *Culex quinquefasciatus* (SHALABY). The frons (Fig. 2, F) almost covers the entire dorsum of the head. It is bounded laterad by the frontal sutures and cephalad by the fronto-clypeal sutures (FCS). The clypeus is divided into the preclypeus and the postclypeus (Prc and Poc). The labrum (Fig. 1, Lr) is composed of the palatum (Pl) and the labral brushes (LB). The antennae (A) are short and slender, with two short, papilliform and sensory processes attached distad.

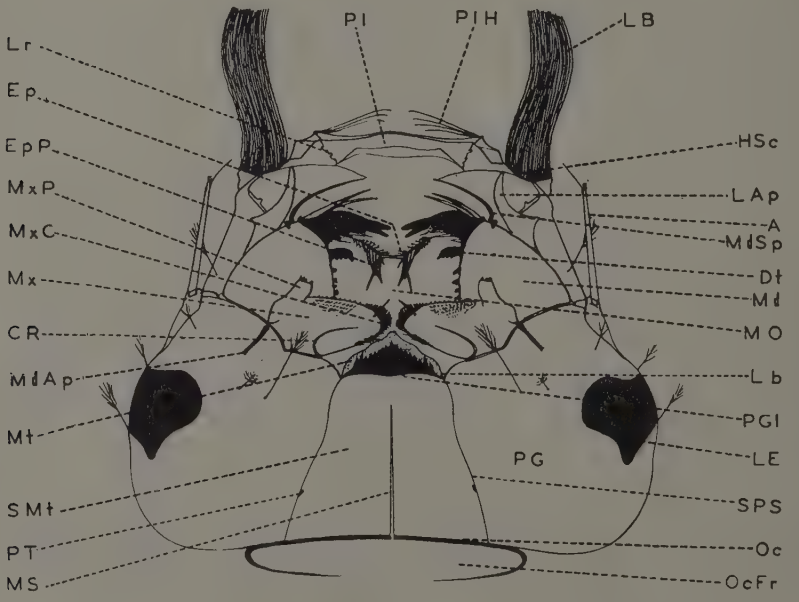


FIG. 1 : Dorsal aspect of the head of the fourth instar larva.

The larval eyes (LE) are large and located on the ocular lobes of the head, laterad of the postgenae (PG). The labium (Lb) is on the meso-caudal region of the ventral aspect of the head. The submentum (SMt) is roughly quadrangular in shape and is separated from the postgenae by the submental-postgenal sutures (SPS). The median suture (MS) runs along the middle of the submentum and extends only a short distance cephalad. The submentum extends from the mentum (Fig. 1, Mt) to the margin of the occipital foramen (OcFr). The cephalic part of the labium is

composed of the mentum and the paraglossa (PGl). The glossa is apparently absent in all the instars of this species. However, in *Anopheles quadrimaculatus*, *Aedes aegypti* and *Culex quinquefasciatus*, the glossa and the paraglossa are present (SHALABY). The maxillae and the mandibles (Mx and Md) are modified to adapt the predacious method of feeding in the predacious instars while in the first instar they are fitted for the filtering method of feeding. The mouth opening (MO) is formed by the epipharynx (Ep) above and the hypopharynx below, with the mandibles and the maxillae forming the side walls.

II. THE MOUTH PARTS OF THE FOURTH INSTAR LARVA

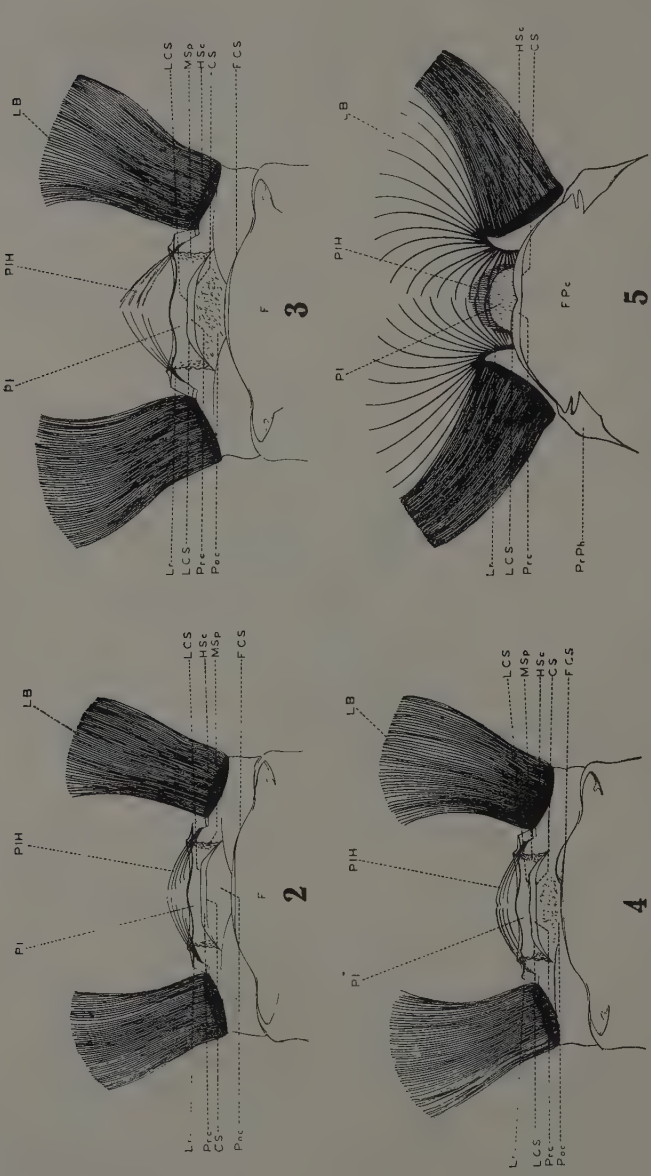
The head capsule of the fourth instar larva is about 1.908 mm. in width. The mouth parts are adapted for the predacious feeding habit.

The writer thinks that the main grabbing apparatus in the larval head are the mandibles. However, the mouth parts in general are considerably armed to fit the predacious habit of the larva.

The labrum

The labrum (Fig. 2, Lr) is composed of a median palatum and the lateral labral brushes. The labrum is separated from the clypeus by a short and slender labro-clypeal suture (LCS). The clypeus is divided by the clypeal suture (CS) into the preclypeus and the postclypeus. The lateral ends of the labro-clypeal suture and the clypeal suture bend caudo-laterad where they meet each other after a short distance. The preclypeus is narrow and is slightly sclerotized and pigmented. The postclypeus is wide, slightly sclerotized and lightly pigmented. It is bounded caudad by the fronto-clypeal suture (FCS). The preclypeus does not possess the preclypeal hairs described by the author in *Anopheles quadrimaculatus*, *Aedes aegypti* and *Culex quinquefasciatus*.

The palatum (Fig. 2 and Fig. 6, Pl) is characterized by its sclerotized nature and its broad shape. Its cephalic margin is heavily pigmented and sclerotized. It is convex mesad and slightly concave laterad. There are few minute microspines (Fig. 2, MSp) which arise from the lateral regions of the ectal surface of the palatum. There are no ental palatal hairs or spines arising from the ental surface of the palatum. There are two quadrangular shaped sclerites which connect the hair-bearing sclerites (Fig. 2 and Fig. 6, HSc) with the sclerotized and pigmented lateral ends of the cephalic margin of the palatum. These two quadrangular-shaped sclerites carry the palatal hairs (Fig. 2 and Fig. 6, PlH) along the mesal margin of their ectal surfaces. The palatal hairs are elongate, fine and range from ten to twelve in number, with five to six hairs on each side. They extend meso-cephalad. It should be noted that the suprapalatal hairs which occur in the labrum of *Aedes aegypti* and *Gulex quinquefasciatus* (SHALABY) are absent here.



FIGS. 2-5 : Dorsal aspect of the cephalic region of the (2) fourth, (3) third, (4) second, and (5) first instar larval head, respectively.

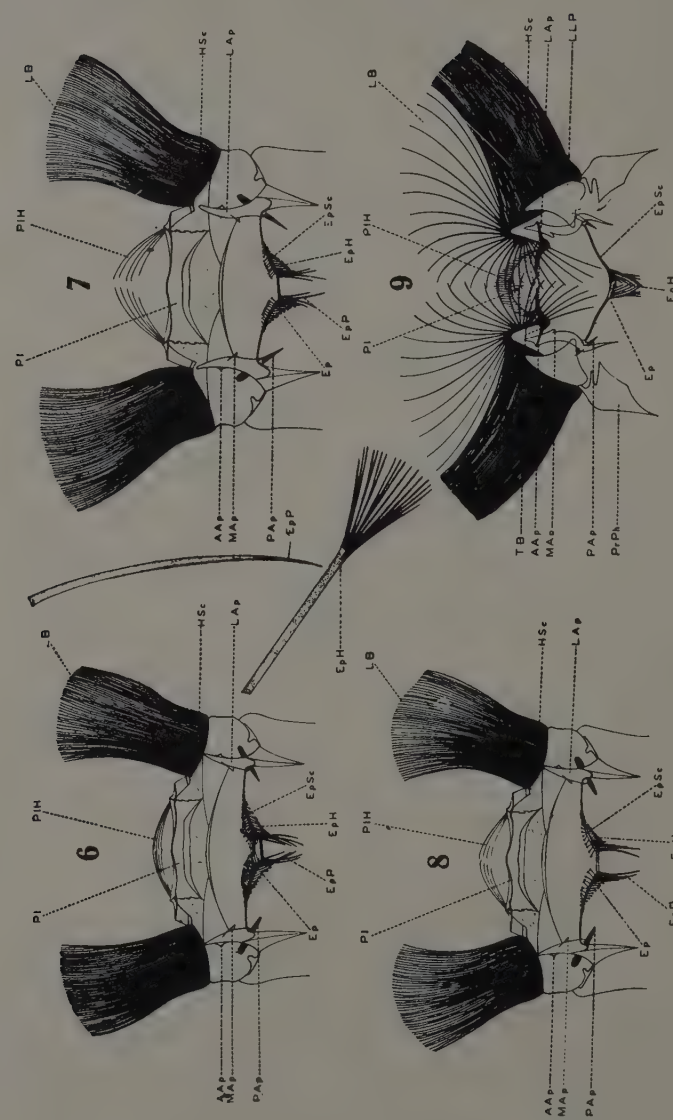
The labral brushes (Fig. 2 and Fig. 6, LB) are relatively long, strong and extend cephalad. The hairs of the labral brush are all serrated and slightly curved. In *Aedes aegypti*, only part of the hairs are pectinate (SHALABY). Under high magnifications, the hairs of the labral brushes (Fig. 10, HLB) are serrated along the entire length of their mesal margins. These serrations are triangular-shaped, sharply pointed, long distad and shorten gradually laterad which cover almost the entire length of the mesal margin of the labral hair. The labral brush consists of one group of hairs which is formed of several series that lie on top of each other.

The apodemes of the labral brushes are internal invaginations which serve for the support of the labral brushes, as well as for muscular attachment. They are composed of two labral apodemes (Fig. 6, LAp) which are located on the sides of the ental aspect of the labrum, caudad of the hair-bearing sclerite (HSc). The two lateral labral plates and the transverse bar which occur in the labrum of *A. quadrimaculatus*, *A. aegypti* and *C. quinquefasciatus* (SHALABY) are absent here. The labral apodeme in *P. ciliata*, however, is highly sclerotized, heavily pigmented and relatively short, with its proximal end pointed, and its distal end fits in the caudal margin of the hair-bearing sclerite. Each labral apodeme possesses three processes. The anterior process of the labral apodeme (AAp) is short, triangular-shaped and attached to the proximal end of the distal third of the lateral margin of the labral apodeme. The medial process of the labral apodeme (MAp) is attached to the mesal margin of the medial third of the labral apodeme. It is short, sharply pointed and extends meso-cephalad. The posterior process of the labral apodeme (PAp) is attached to the distal end of the proximal third of the labral apodeme. It is relatively long, more or less stout, sclerotized and extends meso-caudad. The proximal third of the labral apodeme is wide and is composed of two parts, a lateral triangular-shaped lightly pigmented part, and a mesal more slender but heavily pigmented part. Attached to the distal end of the mesal margin of the proximal third of the labral apodeme is a small and rounded membranous area to which is attached the lateral end of the epipharyngeal sclerite (EpSc).

The epipharynx

The epipharynx (Fig. 6, Ep) is located mesad, on the ental aspect of the labrum, between the proximal thirds of the labral apodemes. It is composed of the narrow epipharyngeal sclerite (EpSc) the epipharyngeal hairs (EpH), and the epipharyngeal processes (EpP). The epipharyngeal sclerite extends horizontally with its lateral extremities attached to the small rounded membranous areas which are connected with the distal ends of the mesal margins of the proximal thirds of the labral apodemes. This sclerite is arched caudad at the mesal region and is more slender laterad than mesad.

The epipharyngeal hairs arise from the mesal region of the epipharyngeal sclerite. They are long mesad and shorten gradually laterad. Under high magni-



FIGS. 6-9 : Ventral aspect of the cephalic region of the (6) fourth, (7) third, (8) second, and (9) first instar larval head, respectively.

fications, the epipharyngeal hair is found to be brush-shaped. It is more or less stout proximad, with a relatively long stem which divides distad into numerous fine short branches. A few simple hairs also arise from the mesal region of the epipharyngeal sclerite. The epipharyngeal processes are connected with the caudal margin of the mesal region of the epipharyngeal sclerite. They are slightly curved and range from 10 to 12 in number with five to six processes on each side of the meson. These processes are spine-like, rigid, pigmented and serrated along the mesal margin of their distal two-thirds. These serrations are very short, fine and slender, which can only be seen under higher magnifications.

The mandibles

The mandibles (Figs. 14 and 18) are large, strong, highly sclerotized and heavily pigmented. They are the main grasping apparatus in the head of the larva. Each mandible is roughly quadrangular in shape and the dentes are arranged along the mesal margin. The dentes can be divided into two groups; the ventral group (VDt) and the dorsal group (DDt).

The ventral dentes consist of two large, serrated cephalic teeth, and two small caudal projections which are produced into sharply pointed short teeth. The most cephalic serrated tooth is elongate, stout and bears four serrations along its caudal margin. The second serrated tooth is located caudad of the cephalic tooth, and is slightly shorter. It bears four serrations also on its caudal margin, which are more slender than those of the cephalic tooth. Caudad of the second serrated tooth, the mesal margin is provided with a small sclerite which is produced into two or three short spine-like teeth. Further caudad, is another sclerite which is long enough to extend to the proximal end of the mesal margin. It is provided with seven or eight spine-like teeth of various sizes.

The dorsal dentes consist of one strong dent (DDt) which lies dorsad of the cephalic ventral tooth. It is curved and not serrated with its distal end beak-shaped and directed meso-caudad. There are two spine-like processes which are referred to as the mandibular arms (MdA), which arise from the mesal end of the cephalic margin, laterad of the cephalic dentes. They are slightly sclerotized and pigmented. In *Aedes aegypti* there is only one mandibular arm, while in *Anopheles quadrimaculatus* and *Culex quinquefasciatus* there is none (SHALABY). It is interesting to notice that the membranous process which was described by the author in the mandibles of the larvae of the three species previously mentioned is absent in *P. ciliata*. Thus, the membranous process is characteristic of the mandibles of the mosquito larvae with a non-predacious feeding habit. The meso-caudal margins of the mandible are sclerotized and pigmented along their entire length. The ventral meso-caudal margin ends meso-cephalad in a large, pigmented and triangular-shaped area which is probably homologous to the mola of the mandible in other insects. Connected with the caudal end of this triangular-shaped sclerite is a tendon (Td). The dorsal meso-caudal

margin is also widened at its meso-cephalic end and divides into fine and relatively short branches which extend mesad.

The mandible is articulated to the ventral wall of the head capsule by the preartis and the postartis (PrA and poA). The articulation is strengthened by the mandibular apodeme (MdAp) which is an invagination from the ventral wall of the head. It is relatively long, and highly sclerotized. The lateral margin of the mandible is convex. At its meso-cephalic end is situated a slightly pigmented area from which arises a relatively slender lateral bristle (LBr), which has a small tubular process at its base. A mandibular comb (MdC), which consists of 12 to 14 setae arises from the meso-cephalic region of the dorsal aspect of the mandible and extends mesad. These setae are slightly curved and are long cephalad and shorten gradually caudad. The comb arises on a relatively short sclerite (Fig. 18, ScC). In the larva of *Aedes aegypti*, the mandibles possess a mandibular comb in addition to the mandibular brush (SHALABY), but the author thinks this mandibular comb is not analogous with that of *P. ciliata*. The writer believes, that the mandibular brush in the filtering and the grazing feeding larvae, whose function is to comb out the food particles off the labral brushes during the feeding process, has probably lost its main function due to the change of the larval feeding habit of *P. ciliata*, to the predacious type, and has become modified to the small but strong comb.

The maxillae

The maxillae (Figs. 22 and 23) are oval in shape. Each maxilla is composed of the galea (Ga), the lacinia (Lc), the cardostipes (CdSt) and the maxillary palpus (MxP). The mesal margin of the maxilla is more or less straight. Its cephalic region is provided with a number of setae which are short, rigid, and extend meso-cephalad. The chitinous ridge (CR) is heavily pigmented. It runs across the middle of the maxilla between the galea and the lacinia and eventually curves meso-caudad to become fused with the entoparartis. The ridge is stouter caudad and slender cephalad where it ends in a point at its distal end, before it reaches the cephalic end of the maxilla.

The maxilla is articulated to the ventral wall of the head capsule by the mesal entoparartis and the lateral exoparartis (Enp and Exp). This articulation is strengthened by the maxillary apodeme (Fig. 22, MxAp), which is an invagination of the ventral wall of the head. The maxillary palpus is short, relatively stout, and bears four sensoria (Figs. 22 and 23, S) at its distal end. The sensoria are short and lightly pigmented. The maxillary palpus is borne on the palpifer (Pf) which is quadrangular in shape and not distinctly separated from the palpus. The latero-cephalic region of the maxilla is clothed with a great number of heavily pigmented microspines (MSp). They are large, more pigmented and dense meso-cephalad, and small, less pigmented and less dense latero-caudad. Arising from the cephalic region of the galea is a single maxillary spine (MxSp) which curves meso-cephalad.

The maxillary brush which occurs in most of the filtering and the grazing feeding mosquito larvae is absent here, and instead there are three maxillary combs (MxC). The combs are attached to the meso-cephalic end of the maxilla. Each comb is composed of numerous, relatively short but rigid hairs which may overlap the hairs of another comb. The hairs of each comb arise on a slender but heavily pigmented sclerite which extends longitudinally across the meso-cephalic end of the maxilla. The three combs differ from each other in size. The largest of which is the intermediate comb, while the smallest is the most ventrad. The function of the maxillary comb is not known. There is a relatively short and needle-like spine (Fig. 22, Sp) which is attached to the lacinia.

The labium

The labium (Fig. 1, Lb) is located at the meso-caudal region of the ventral aspect of the head. It is composed of the submentum, the mentum and the paraglossa. The glossa is apparently absent. The submentum (SMt) is sclerotized, pigmented and quadrangular in shape. The two posterior tentorial pits are very prominent. Each posterior tentorial pit is situated at the distal end of the proximal third of the submental-postgenal suture.

The mentum (Fig. 1, Mt, and Fig. 27) is connected with the cephalic end of the submentum. It is quadrangular in shape and extends cephalad beyond the cephalic end of the paraglossa. The mentum is slightly sclerotized with its cephalic region produced into six to nine teeth (Fig. 27, Th) which are, pigmented and sharply pointed. In *A. quadrimaculatus*, *A. aegypti* and *C. quinquefasciatus*, the mentum possesses no teeth (SHALABY).

The paraglossa (Fig. 31) is located dorsad of the mentum. The absence of the glossa presents a significant characteristic for a predacious feeding larva. The paraglossa is triangular in shape and consists of 17 teeth, eight teeth on each side of a disto-central tooth. It is highly sclerotized and heavily pigmented. The three latero-caudal teeth on each side of the paraglossa, are more elongate, stronger and stouter than the others. The median region of the paraglossa is slightly sclerotized and lightly pigmented. Attached to the caudal margin of the paraglossa is a more or less wide, highly sclerotized and heavily pigmented transverse area. The paraglossa, together with the strong mandibles are used in holding as well as crushing the prey.

The hypopharynx

The hypopharynx (Fig. 35) is located dorsad of the paraglossa. It is more or less triangular in shape, highly sclerotized and pigmented. The cephalo-lateral ends of the hypopharynx are connected with the sclerotized and pigmented cibarial bars (CB). The salivary opening is not apparent. The salivary ducts are not observed in this instar, but they can be traced at the caudal end of the hypopharynx of the third instar (Fig. 36, SD). The hypopharynx is armed with about 70 hypophrayngeal

spines (Fig. 35, HypSp) which are scattered at random over the area of the hypopharynx. There is a relatively wide, and heavily pigmented area which runs transversely across the cephalic region of the hypopharynx, with its lateral ends curved caudo-laterad. This transverse area bears the majority of the hypopharyngeal spines. There are two large and highly sclerotized hypopharyngeal processes (HypP), one on each cephalo-lateral region of the hypopharynx. The median region of the hypopharynx bears the rest of the hypopharyngeal spines which are arranged either in groups or singularly. On the sides of the hypopharynx there are several movable spines (MvSp). On one side there are single spines somewhat widely separated. On the other side there are three in one group located on a circular pigmented area and a single spine caudad of the group of three. The paragnatha which were described by the author in *A. aegypti* and *C. quinquefasciatus* are absent here.

III. THE MOUTH PARTS OF THE THIRD INSTAR LARVA

The head capsule of the third instar larva is about 1.071 mm. in width. The larva in this instar, has the same predacious feeding habit as the larva in the fourth instar, but attacks smaller mosquito larvae.

The labrum

The labrum (Fig. 3, Lr) is composed of the palatum and the two labral brushes. The preclypeus (Prc) is narrow and less pigmented than that of the fourth instar. The postclypeus (Poc) is slightly sclerotized and pigmented.

The palatum (Pl) is broad, but less sclerotized and less pigmented than that of the fourth instar. The microspines (MSp) which arise from the lateral regions of the ectal surface of the palatum, are fewer and lighter-coloured than those of the fourth instar. The palatal hairs (Fig. 3 and Fig. 7, PlH) are comparatively fine and range from eight to ten in number, with four or five on each side.

Each labral brush (LB) consists of numerous serrated hairs which are less dense and a little shorter than those of the fourth instar. Under high magnifications, the hairs of the labral brush (Fig. 11) are slightly curved, pigmented and serrated along their mesal margin. The sharply pointed serrations are comparatively few and covers almost the entire mesal margin of the hair.

As in the fourth instar, there is only one pair of labral apodemes (Fig. 7, LAp). Each labral apodeme is sclerotized, pigmented and elongate, with its distal end rounded, while that of the fourth instar is pointed. The anterior, medial and posteriore processes of the labral apodeme (AAp, MAp and PAp) are present, though they are small and slightly pigmented. Attached to the distal end of the mesal margin of the proximal third of the labral apodeme is a small, rounded membranous area, as in the fourth instar, except that it is less pigmented.

The epipharynx

The epipharynx (Fig. 7, Ep) is composed of the epipharyngeal sclerite (EpSc), the epipharyngeal hairs (EpH), and the epipharyngeal processes (EpP). The epipharyngeal sclerite is more slender, less sclerotized and less pigmented than that of the fourth instar. It is stout mesad, slender laterad and arched caudad in the mesal region. Its lateral extremities are connected with the small rounded membranous areas which are attached to the proximal thirds of the two labral apodemes. The epipharyngeal hairs are fewer, lighter coloured and a little shorter than those of the fourth instar. They do not overlap each other as much as those of the fourth instar. The simple hairs which arise from the mesal region of the epipharyngeal sclerite in the fourth instar are absent in the third instar. The epipharyngeal processes are slightly pigmented, comparatively short and range from eight to ten in number, with four to five processes on each side of the meson. As in the fourth instar, each epipharyngeal process, under high magnifications, is sharply pointed and is provided with tiny fine processes along its distal two-thirds.

The mandibles

The mandibles (Figs. 15 and 19) are comparatively small and slightly sclerotized. The ventral dentes (Figs. 15 and 19, VDt) consist of two large and strong cephalic serrated teeth, and one caudal area which is produced into short but sharply pointed spine-like teeth. The cephalic serrated tooth is provided with three triangular-shaped serrations along its caudal margin. In the fourth instar there are four serrations. The second serrated tooth is provided with four slender serrations as in the fourth instar. The caudal sclerite is small and produced into five to six small teeth. The dorsal dent (DDt) is strong and curved, but shorter than in the fourth instar. The mandibular arms which are present in the fourth instar are absent in third instar; and if present, they are poorly developed. The meso-caudal margins of the mandible are sclerotized and pigmented along their entire length. The ventral meso-caudal margin is very slightly widened at its disto-mesal end. The dorsal meso-caudal margin is also slightly widened at its disto-mesal end, and is provided with a number of fine hairs which are fewer, lighter-coloured and shorter than those of the fourth instar. Attached to the disto-mesal end of the meso-caudal margins of the mandible is the tendon (Td).

The mandible is articulated to the ventral wall of the head by the preartis and the postartis (PrA and PoA). The articulation is strengthened by the mandibular apodeme (MdAp). The convex latero-cephalic margin of the mandible ends distad in a slightly pigmented and sclerotized area, which bears the lateral bristle (LBr), which is lightly-coloured and slightly curved. The mandibular comb (MdC) is composed of 12 to 14 setae, as in the fourth instar. However, they are more slender, lighter-coloured and a little shorter. The comb arises on a heavily pigmented sclerite (Fig. 19, ScC).

The maxillae

The maxillae (Fig. 24) are comparatively small. The meso-caudal margin of the maxilla is roughly straight. It is provided along its distal region with setae, which are fewer, shorter and lighter-coloured than those of the fourth instar. The chitinous ridge (CR) is slightly sclerotized and lightly pigmented and extends longitudinally across the middle of the maxilla. The maxilla is articulated to the ventral wall of the head by the entoparartis and the exoparartis (Enp and Exp). The articulation is strengthened by the maxillary apodeme (MxAp).

The maxillary palpus (MxP) is a little shorter and less pigmented than that of the fourth instar. On its distal end are four sensoria (S), as in the fourth instar. However, they are shorter, lighter-coloured and more slender. The palpifer (Pf) is more slender and less pigmented than that of the fourth instar. The latero-cephalic margin of the maxilla is provided with numerous microspines (MSp), which are comparatively few, and lightly-coloured. As in the fourth instar, there are three maxillary combs (MxC) which are attached to the meso-cephalic end of the maxilla, though they contain fewer setae. The needle-like spine (Sp) which arises from the dorsal aspect of the lacinia (Lc) is a little shorter and less pigmented than that of the fourth instar. In general, the maxilla of the third instar resembles, to a great extent, that of the fourth instar.

The labium

The labium is less sclerotized and less pigmented than in the fourth instar. The glossa is apparently absent. The submentum which occupies the meso-caudal region of the ventral aspect of the head, is comparatively small. There is no illustration here for the submentum because of its similarity to that of the fourth instar.

The mentum (Fig. 28) is small and slightly sclerotized. Its cephalic margin is sinuate, thus differing from that of the fourth instar. The meso-cephalic region of the mentum is produced into five to eight teeth (Th) which are comparatively small.

The paraglossa (Fig. 32) is less sclerotized and less pigmented than that of the fourth instar. As in the fourth instar, it is composed of 17 teeth, with eight teeth on each side of the disto-central tooth. The median region is slightly sclerotized and lightly pigmented, with its caudal region heavily pigmented. The heavily pigmented sclerite which is attached caudad of the paraglossa in the fourth instar is absent here.

The hypopharynx

The hypopharynx (Fig. 36) is comparatively small and slightly sclerotized. It bears about the same number of hypopharyngeal spines (HypSp), as in the fourth instar. Most of the teeth are arranged along the heavily pigmented transverse area which runs across the cephalic region of the hypopharynx. This transverse area is more slender than that of the fourth instar. The salivary duct can be seen penetrating

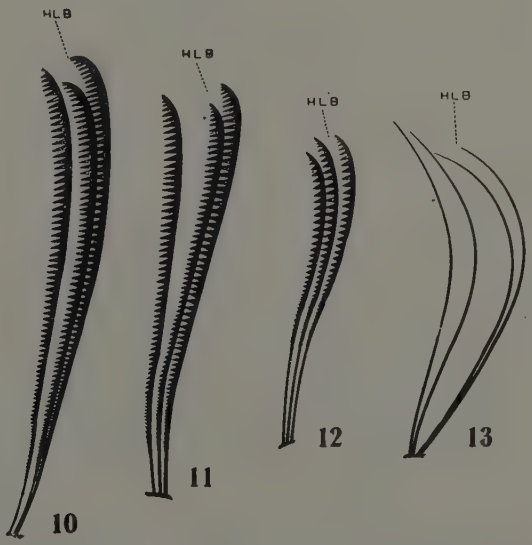
through the caudal region of the hypopharynx. There are two large and heavily pigmented hypopharyngeal processes (HypP), one on each side of the hypopharynx. The two pairs of movable spines (MvSp) are more slender, and a little shorter than those in the fourth instar.

IV. THE MOUTH PARTS OF THE SECOND INSTAR LARVA

The head capsule of the second instar larva is about 0.670 mm. in width. The larva is a predacious feeder as the third and fourth instar larvae.

The labrum

The labrum (Fig. 4, Lr) is composed of the palatum and the two labral brushes. The labro-clypeal suture (LCS) is more sinuate than that of the third instar. The fronto-clypeal suture (FCS) is narrower and lighter-coloured than that of the third and fourth instar.



FIGS. 10-13 : Hairs of the labral brush of the (10) fourth, (11) third, (12) second, and (13) first instar larva, under high magnification, respectively.

The palatum (Fig. 4 and Fig. 8, Pl) is narrower, less sclerotized and less pigmented than that of the third instar. The palatal hairs (PlH) are fine, lightly-coloured and extend meso-cephalad. They are eight in number, with four hairs

on each side, equal to those of the third instar. The microspines (Fig. 4, MSp) are comparatively few and lightly-coloured.

The labral brushes (Fig. 4 and Fig. 8, LB) are less dense, shorter and lighter-coloured than those of the third and fourth instars. The hairs of the labral brushes (Fig. 12) are serrated as in the older instars. However, the serrations are relatively short and extend only along the distal two thirds of their mesal margins.

As in the third and fourth instars, the apodemes consists of the two labral apodemes (Fig. 8, LAp). The labral apodeme is comparatively slender, slightly sclerotized and lightly pigmented. The anterior, medial and posterior processes of the labral apodeme (AAp, MAp and PAp) are present, but comparatively small. There is a rounded membranous area attached to the middle of the mesal margin of the labral apodeme.

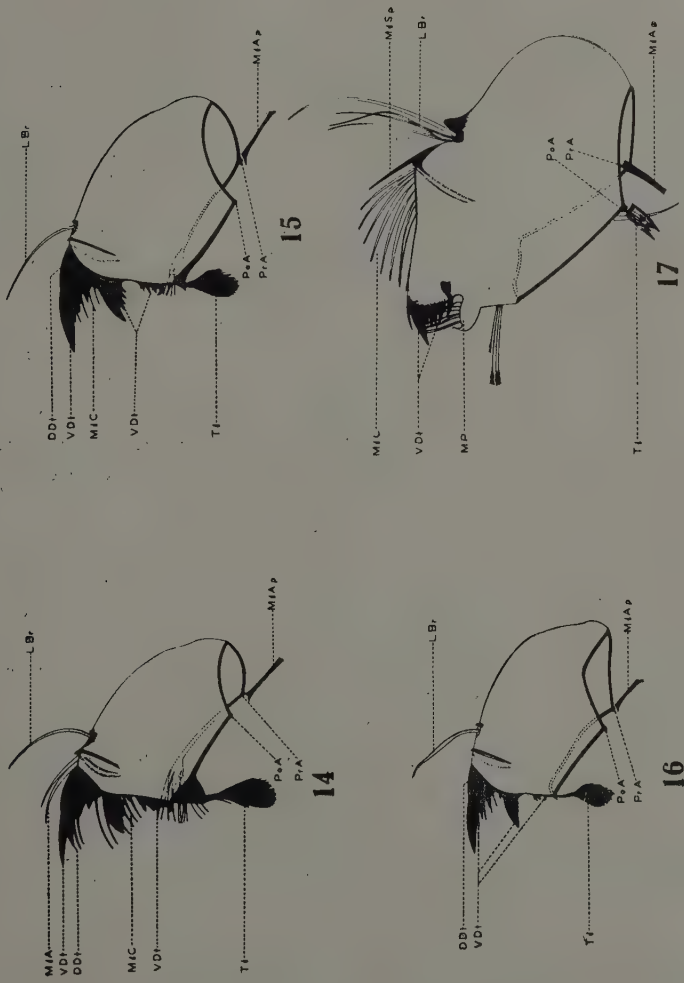
The epipharynx

The epipharynx (Fig.8,Ep) is composed of the epipharyngeal sclerite (EpSc), the epipharyngeal hairs (EpH) and the epipharyngeal processes (EpP). The lateral extremities of the epipharyngeal sclerite are connected with the small, rounded membranous areas which are attached to the middle of the labral apodeme. The epipharyngeal hairs are brush-shaped, similar to those of the older instars thouhg they are fewer, shorter and lighter-coloured. The simple hairs which are attached to the mesal region of the epipharyngeal sclerite in the fourth instar, are absent here too. The epipharyngeal processes are six in number. They are similar in structure, to those of the older instars though they are less sclerotized and pigmented.

The mandibles

The mandibles (Figs. 16 and 20) are smaller than those of the third instar. They are strong enough to sieze a small prey and manoeuvre it through the mouth cavity with the help of the labral brushes. The ventral dentes (VDt) consist mainly of the two large serrated teeth. The cephalic tooth is slender and provided with three serrations. The caudal tooth is comparatively short, slightly sclerotized and provided with three serrations only. The elongate caudal sclerite which is attached to the caudal end of the mesal margin of the mandible is poorly developed and produced into five or six short spine-like teeth. The dorsal dent (DDt) is a little shorter, and less pigmented than that of the third instar. The mandibular arms of the mandibles of the fourth instar larva are absent here too.

The meso-caudal margins of the mandible are sclerotized and pigmented along their entire length, though they are comparatively slender. The ventral meso-caudal margin is not widened at its meso-cephalic end.The dorsal meso-caudal margin is not provided with setae at its meso-cephalic end. The tendon (Td) is comparatively small and slightly sclerotized. The mandible is articulated to the ventral wall of the head by the preartis and the postartis (PrA and PoA), as in the older instars. The articulation is strengthened by the mandibular apodeme (MdAp). The lateral bristle



FIGS. 14-17 : Ventral aspect of the left mandible of the (14) fourth, (15) third, (16) second, and (17) first instar larva, respectively.

(LBr) is less pigmented than that of the third and fourth instars. The mandibular comb (Fig. 20, MdC) consists of 11 and sometimes, but not often, 12 setae. These setae are shorter, lighter-coloured and more slender than those of the older instars.

The maxillae

The maxillae (Fig. 25) are comparatively small and slightly sclerotized. The meso-caudal margin is provided with a few setae, which are finer and lighter-coloured than those of the third and fourth instars. The chitinous ridge (CR) is comparatively slender. As in the older instars, the maxilla is articulated to the ventral wall of the head by the entoparartis and the exoparartis (Enp and Exp). The maxillary apodeme is absent in this instar. The maxillary palpus (MxP) is much shorter and less pigmented than in the third and fourth instars. The sensoria (S) are short, slender and equal in number to those of the older instars. The palpifer (Pf) here is hard to distinguish, as the suture which separates it from the palpus is obsolete.

The latero-cephalic margin of the maxilla is provided with microspines (MSp) which are fewer than those of the older instars. The maxillary spine (MxSp) which arises from the cephalic region of the galea (Ga) is comparatively short and lightly pigmented. The three maxillary combs (MxC) consist of fewer, shorter and lighter-coloured setae than those of the third instar. The needle-like spine (Sp) which arises from the cephalic region of the lacinia (Lc) is relatively slender.

The labium

The labium consists of the submentum, mentum and the paraglossa. As in the third and fourth instars, the glossa is absent. The submentum is comparatively small in size, slightly sclerotized and lightly pigmented.

The mentum (Fig. 29) is quadrangular in shape with a slightly sinuate cephalic margin. The mesal region of the cephalic margin is produced into four or five teeth which are smaller and lighter-coloured than in the third instar.

The paraglossa (Fig. 33) is comparatively small, slightly sclerotized and lightly pigmented. It is composed of 17 teeth, with eight teeth on each side of the disto-central tooth, as in the third and fourth instars. The most caudo-lateral tooth is poorly developed, while it is elongate and well developed in the older instars. The caudal sclerotized area of the paraglossa is much narrower than in the third instar.

The hypopharynx

The hypopharynx (Fig. 37) is small in size, less sclerotized and less pigmented than that of the third instar. The hypopharyngeal spines (HypSp) are few, small and lightly pigmented. They are about 50 in number, while in the third and fourth instars there are about 70 spines. The salivary duct (SD) can be seen through the caudal region of the hypopharynx. The movable spines (MvSp) are short and slender.

The hypopharyngeal processes (HyP) are smaller, less sclerotized and less pigmented than in the third and fourth instars.

V. THE MOUTH PARTS OF THE FIRST INSTAR LARVA

The head capsule is about 0.503 mm. in width. It is more or less rounded in shape, thus differing from the quadrate shaped head of the second, third and fourth instars. In this instar, the larva is not predacious. It has the filtering feeding habit. Therefore, the mouth parts are adapted for the filtering feeding method, and looking more like those of *Anopheles quadrimaculatus*, *Aedes aegypti* and *Culex quinquefasciatus* (SHALABY). The egg burster (Fig. 39, EB) which is oval in shape, is quite distinct, and is located at the meso-caudal region of the frons (F). It is composed of a membranous area, with a transverse, pigmented eye-shaped structure in the middle, which includes a pointed and sclerotized spine in the center. The egg burster helps break the chorion of the egg during the hatching process.

The labrum

The labrum (Fig. 5, Lr) is composed of the palatum and the labral brushes. The labro-clypeal suture (LCS) is notched mesad, and curves latero-caudad at the sides of the head. The clypeus is divided by the clypeal suture (CS) into the preclypeus (Prc), and the postclypeus which fuses with the frons to form the fronto-postcypeus (FPc). The fronto-clypeal suture which is present in the second, third and fourth instars, is obsolete here. The paraclypeal phragmata (Figs. 5 and 9, PrPh) are sclerotized and pigmented.

The palatum (Pl) is semi-circular in shape. It is not sclerotized and very lightly pigmented. The two quadrangular shaped sclerites which are located between the lateral ends of the cephalic margin of the palatum and the mesal ends of the hair-bearing sclerites, in the advanced instars, are absent here. The palatal hairs (PlH) arise from the border of the palatum and extend cephalad. They are numerous, relatively short and fine. The ectal and ental surfaces of the palatum are clothed with numerous, short and very fine hairs. The microspines which are located at the lateral regions of the palatum of the advanced instars, are absent here.

The labral brushes (LB) resemble very much those of the filtering feeding *C. quinquefasciatus* and *A. quadrimaculatus*. The hairs of the labral brushes(Fig. 13) are simple. Each labral brush can be divided into three groups of hairs. The largest and the most lateral group consists of dense, long and slightly curved hairs which arise along the entire length of the hair-bearing sclerite (Figs. 5 and 9, HSc). The second and mesal group consists of a few and slightly short hairs which arise from the distal curved part of the hair-bearing sclerite. The third group of hairs is located on the ental surface of the labrum. It consists of more or less straight and relatively short hairs which are fewer than those of the second group. Both the palatum and

the labral brushes move rapidly cephalad and caudad during the feeding process, producing a continuous current of water.

The apodemes of the labral brushes (Fig. 9, LAp, LLP and TB) resemble those of *A. quadrimaculatus*, *A. aegypti* and *C. quinquefasciatus* (SHALABY). The elongate labral apodemes (LAp) are sclerotized and pigmented, with a pointed proximal end, and a somewhat pointed distal end which fits into the arch formed by the curvature of the distal end of the hair-bearing sclerite. The labral apodeme has a convex mesal margin and a concave lateral margin. The anterior, medial and posterior processes of the labral apodeme (AAp, MAp, and PAp) are present. They are smaller and less pigmented than in the advanced instars. Attached to the distal end of the proximal third of the mesal margin of the labral apodeme, is a small and more or less membranous area.

The lateral labral plate (LLP) is triangular in shape lightly sclerotized and occupies the gap left between the labral apodeme and the hair-bearing sclerite. Its broad lateral base partially covers the ental aspect of the hair-bearing sclerite, while its somewhat pointed mesal end lies across the median third of the labral apodeme. The lateral labral plate is absent in the predacious-feeding larval instars.

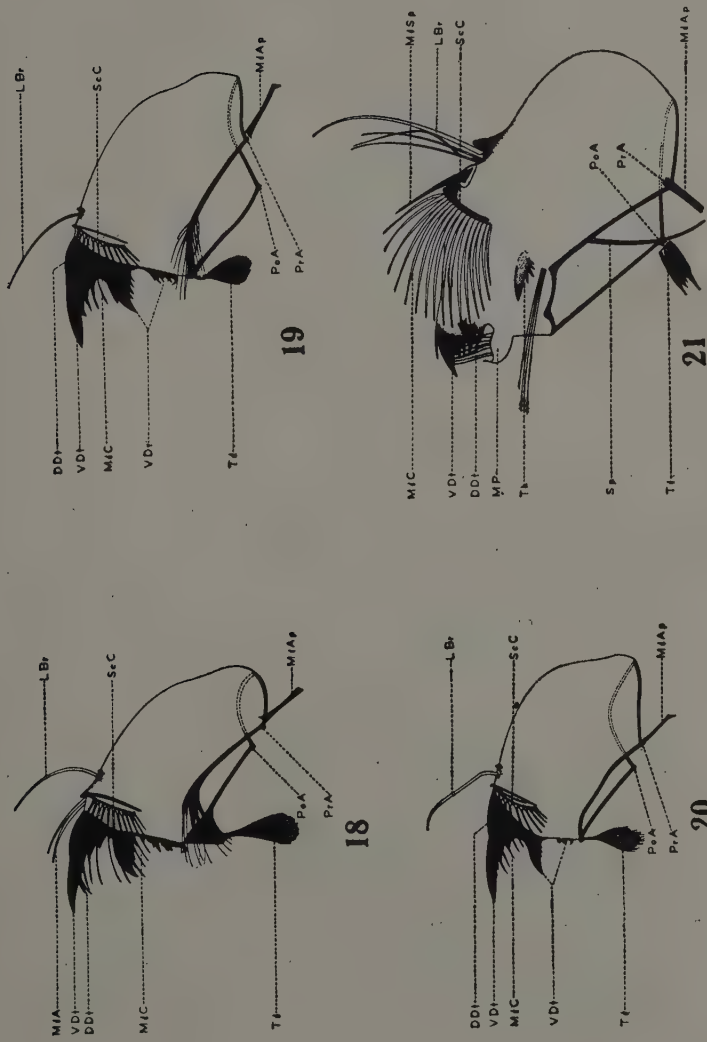
The transverse bar (TB) is heavily pigmented, highly sclerotized and extends transversely on the ental surface of the labrum, between the distal third of the labral apodemes. It is also absent in the predacious-feeding instars. The two symmetrical halves of the transverse bar are not connected with each other mesad. The lateral ends of the transverse bar are connected with the anterior processes of the labral apodemes of both sides.

The epipharynx

The epipharynx (Fig. 9, Ep) is composed of the epipharyngeal sclerite (EpSc) and the epipharyngeal hairs (EpH). The spine-like epipharyngeal processes which occur in the second, third and fourth instars are absent in this instar. The epipharyngeal sclerite is stout mesad and slender laterad. Its lateral extremities are connected with the small membranous areas which are attached to the meso-distal end of the proximal third of the labral apodeme. The epipharyngeal hairs are relatively few, and range from 14 to 20 in number. They are simple, slightly curved, lightly-coloured and relatively short; resembling those of the filtering-feeding mosquito larvae.

The mandibles

The mandibles (Figs. 17 and 21) are adapted for the filtering method of feeding. They are small in size, subquadrangular in shape and lightly pigmented. Unlike those of the advanced instars, the ventral dentes (VDt) are not serrated. They consist of nine short and weak dentes. The dorsal group (Fig. 21, DDt) is located in the caudal region of the dorsal aspect of the dentes-bearing area. They are composed of three small and lightly pigmented teeth which extend mesad. Caudad of the dentes-bearing area is located the membranous process (Figs. 17 and 21, MP) which arises from the middle of the ventral mesal margin of the mandible. A group of four long hairs



FIGS. 18-21 : Dorsal aspect of the right mandible of the (18) fourth, (19) third, (20) second, and (21) first instar larva, respectively.

arises cephalad of the distal end of the ventral mesal margin. Each of these hairs is brush-like, as it is provided with fine short branches at its distal end. A group of five sharply pointed teeth (Th) is located cephalad of the proximal end of the brush-like hairs, on the dorsal aspect of the mandible.

The mandible is articulated to the ventral wall of the head by means of the preartis and the postartis (Figs. 17 and 21, PrA and PoA). The articulation is strengthened by the mandibular apodeme (MdAp). The tendon (Td) is slightly pigmented and attached to the postartis. The lateral margin of the mandible is prominently convex. It ends distad in a sclerotized and pigmented projecting socket which bears the lateral bristles (LBr) which are four in number. A sharply pointed mandibular spine (MdSp) arises from the cephalic region of the dorsal aspect of the mandible, cephalo-mesad of the lateral bristles. This spine is absent in the older instars. The mandibular comb (MdC) is proportionally larger than that of the older instars and lies across the cephalic margin of the dorsal aspect of the mandible. It is composed of 16 to 18 relatively long, stout and sharply pointed setae, which extend meso-cephalad. They arise from a pigmented sclerite (Fig. 21, ScC) which lies across the cephalic region of the dorsal aspect of the mandible.

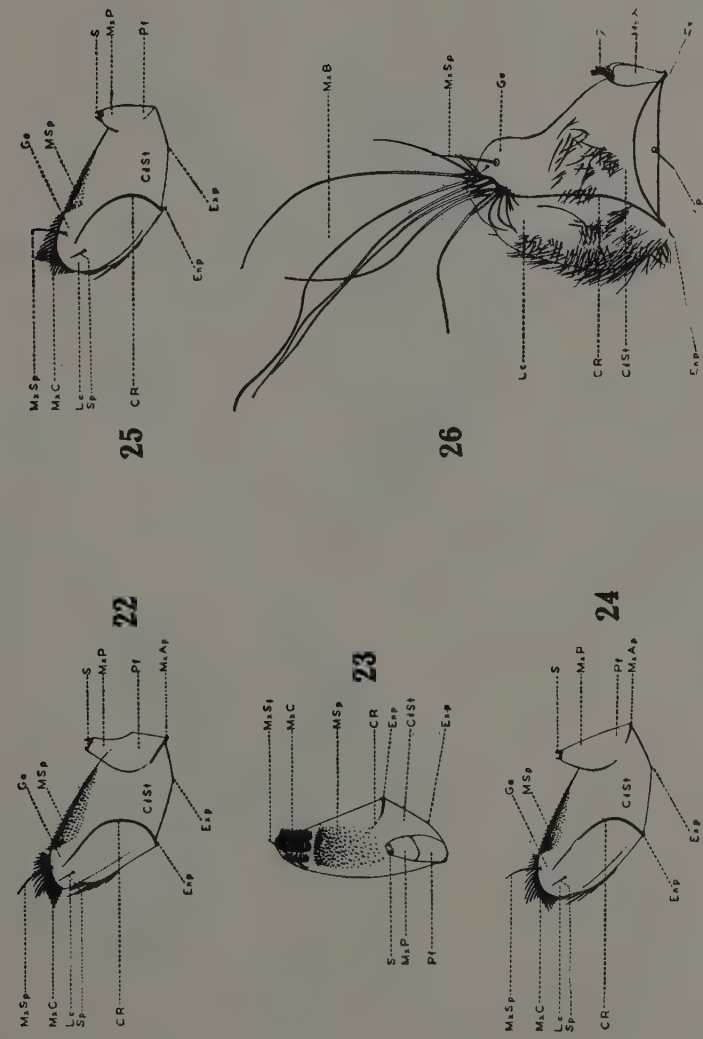
The maxillae

The maxillae (Fig. 26) are also adapted for the filtering method of feeding. Each maxilla is composed of the lacinia (Lc), the galea (Ga), the cardostipes (CdSt), and the maxillary palpus (MxP), as in the advanced instars. The convex mesal margin of the maxilla is clothed with numerous long and fine setae which overlap and tangle with each other. The chitinous ridge (CR) is slender, sclerotized and extends between the galea and the lacinia cephalad until it reaches the cardostipes caudad, where it curves meso-caudad to fuse with the entoparartis. The maxilla is articulated to the ventral wall of the head by means of the entoparartis and the exoparartis (Enp and Exp). The maxilla is also articulated along the entire length of the caudal margin. There is a relatively short spine (Sp) which arises from the caudal region of the maxilla.

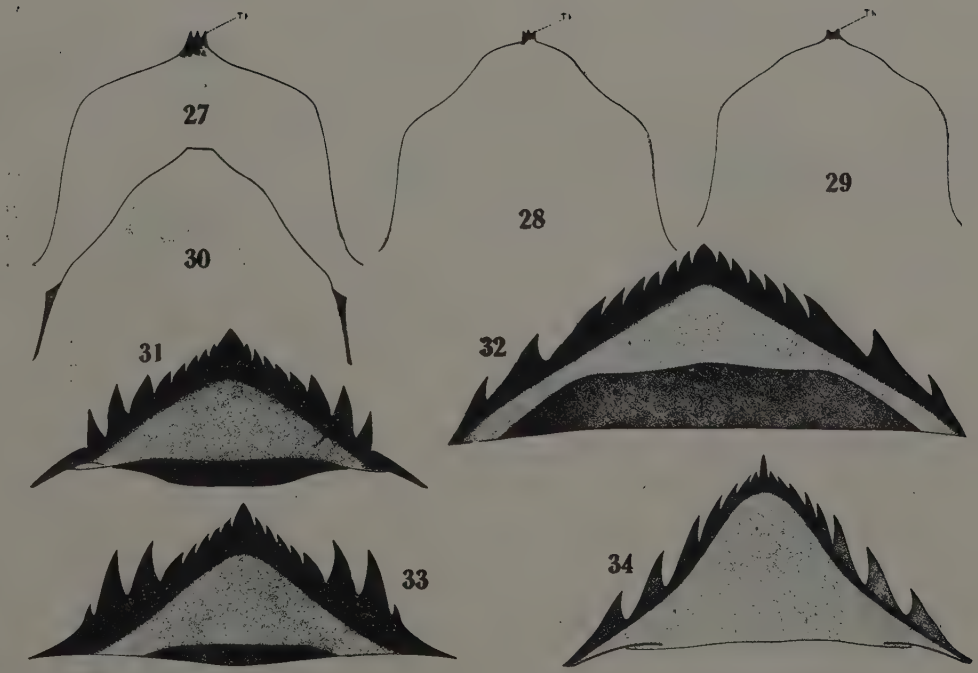
The maxillary palpus (MxP) is shorter, less sclerotized, and less pigmented than that of the older instars. The palpifer is obsolete. There are six short and papilliform sensoria (S) at the distal end of the palpus. The lateral margin of the maxilla is slightly sinuate. The microspines which arise on the cephalo-lateral region of the maxillae of the predacious-feeding larvae, are absent here. A long and pigmented maxillary spine (MxSp) arises from the cephalic region of the galea. The three maxillary combs of the predacious-feeding instars are absent. They are replaced by a maxillary brush (MxB), which consists of 15 to 18 slender and sharply pointed hairs. The hairs are longer laterad and shorten gradually mesad.

The labium

The labium is composed of the submentum, mentum and the paraglossa as n the advanced instars. The glossa is absent.



FIGS. 22-26 : Ventral aspect of the left maxilla of the (22) fourth, (24) third, (25) second and, (26) first instar larva, respectively; (23) lateral aspect of the left maxilla of the fourth instar larva.



FIGS. 27-30 : Ventral aspect of the mentum of the (27) fourth, (28) third, (29) second, and (30) first instar larva, Figs. 31-34 : Ventral aspect of the paraglossa of the (31) fourth, (32) third, (33) second, and (34) first instar larva, respectively.

The submentum is much smaller, less sclerotized and less pigmented than in the older instars.

The mentum (Fig. 30) is triangular in shape. It is very lightly sclerotized and pigmented. The spine-like teeth which arise from the mesal region of the cephalic margin in the predacious feeding instars are absent here.

The paraglossa (Fig. 34) is less sclerotized and less pigmented than in the advanced instars. It is composed of 16 teeth, eight teeth on the left side, seven teeth on the right side and a single slender disto-central tooth. The caudal sclerotized and pigmented area which occurs in the paraglossae in the older instars is absent here.

The hypopharynx

The hypopharynx (Fig. 38) is entirely different in shape and construction from those of the older instars. It is more or less bilaterally symmetrical. The salivary ducts are not apparent. There are two longitudinal and pigmented sclerites which are bifurcate caudad and extend cephalo-laterad. The hypopharyngeal spines (HypSp) are much fewer and proportionally larger than those of the advanced instars. The hypopharyngeal processes (HypP) are relatively large and sharply pointed, and are located together with the movable spines (MvSp) on the cephalo-lateral regions of the hypopharynx.

VI. SUMMARY OF THE IMPORTANT INSTAR DIFFERENCES

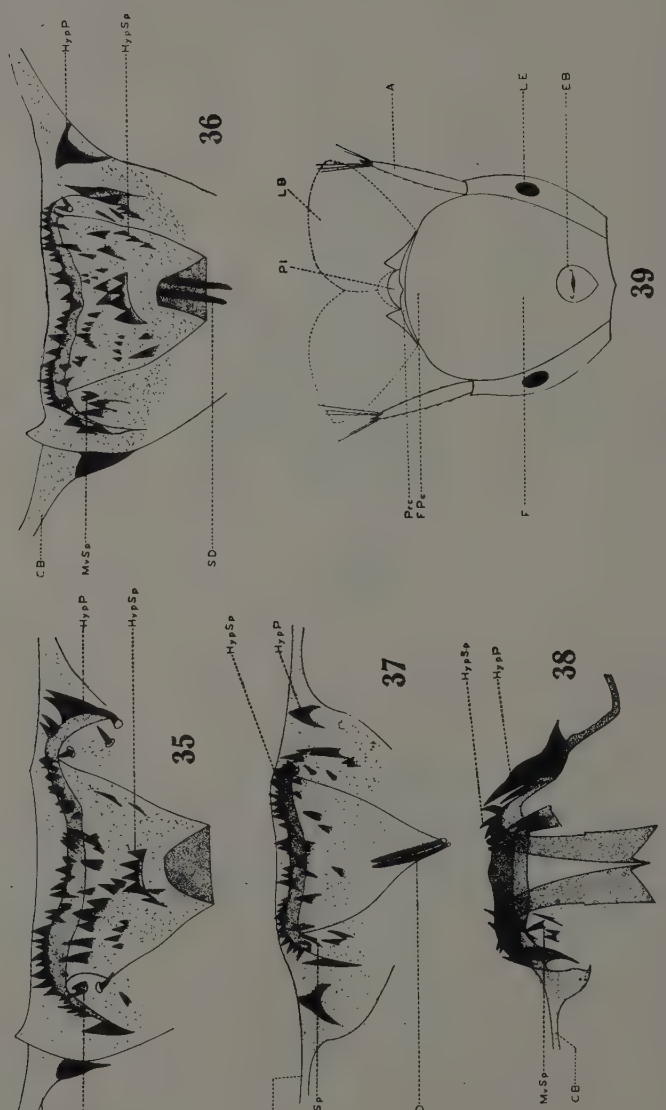
Of the significant differences, is the change of the feeding habit after the first larval moult. The first instar larva has the filtering feeding habit while the larvae in the second, third and fourth instars are predators.

The egg burster occurs only in the first instar.

The labral brushes of the first instar are composed of simple hairs. Those of the second, third and fourth instars are composed of serrated hairs. The palatum in the first instar is semi-circular and provided with numerous palatal hairs. In the advanced instars, the palatum is quadrangular in shape and possesses eight palatal hairs in the second and third instars and ten palatal hairs in the fourth instar. The apodemes of the labral brushes in the first instar consist of two labral apodemes, two lateral labral plates and a transverse bar. In the predacious-feeding instars, the apodemes consist only of the two labral apodemes.

The epipharyngeal hairs in the first instar are few and simple. Those of the second, third and fourth instars are numerous and brush-like.

The ventral dentes of the mandible of the first instar are short and unserrated, while those of the predacious-feeding instars are strong and serrated. The cephalic serrated tooth in the second and third instars possesses three serrations, while that of the fourth instar possesses four serration. The caudal serrated tooth in the second instar possesses three serrations, while that of the third and fourth instars possesses



FIGS. 35-38 : Ventral aspect of the hypopharynx of the (35) fourth, (36) third, (37) second, and (38) first instar larva, respectively.
FIG. 39 : Dorsal aspect of the head of the first instar larva, showing the egg burster.

four serrations. The dorsal dentes of the first instar consist of three small dentes. Those of the advanced instars consist of a single dent. The mandibular arms are absent in the first, second and third instars and present in the fourth instar. The lateral bristles are four in number in the mandible of the first instar, and only one in the older instars. The membranous process is present in the mandible of the first instar, but lacks from the mandibles of the predacious instars.

The maxilla of the first instar is triangular in shape, while in the older instars it is oval in shape. The maxillary brush is present only in the first instar which becomes replaced after the first moult by three short maxillary combs.

The mentum of the first instar is triangular in shape and contains no teeth at its meso-cephalic end. The mentum in the advanced instars is subquadrangular in shape and provided with teeth at the meso-cephalic end. There are four or five teeth in the second instar, five to eight in the third instar and six to nine in the fourth instar.

The paraglossa of the first instar is lightly sclerotized and consists of 16 teeth. The paraglossae in the predacious-feeding instars are sclerotized and composed of 17 teeth.

The hypopharynx of the first instar is slightly pigmented and more or less bilaterally symmetrical. It possesses a few hypopharyngeal spines. The hypopharynx in the advanced instars is quadrangular in shape and not bilaterally symmetrical. The number of the hypopharyngeal spines, the degree of sclerotization and the degree of pigmentation increases after the first, second and third moults.

VII. KEY TO THE LARVAL INSTARS OF P. CILIATA (FABRICIUS) BASED ON THE HEAD STRUCTURES

1. Larva with predacious feeding habit. Egg burster on dorsal side of frons, absent. Hairs of labral brush serrated. Palatum quadrangular. Labral brushes, with two labral apodemes only. Head more or less quadrate. Epipharyngeal hairs, brush-shaped. Ventral dentes of mandible serrated. Membranous process of mandible absent. Mandible with one lateral bristle. Maxilla oval-shaped, with no brush. Mentum with teeth at its mesocephalic region. Paraglossa with 17 teeth and heavily sclerotized. Hypopharynx not bilaterally symmetrical 2

1a. Larva with filtering feeding habit. Egg burster on dorsal side of frons present (Fig. 39, EB). Head rounded and about 0.503 mm. in width. Hairs of labral brush simple. Labral brushes with two labral apodemes, two lateral labral plates and a transverse bar (Fig. 9, LAp, LLP, and TB). Palatum semi-circular (Figs. 5 and 9, Pl). Epipharyngeal hairs simple (Fig. 9, EpH). Ventral

dentes of mandible not serrated (Figs. 17 and 21, VDt). Mandible with three small dorsal dentes (Fig. 21, DDt) . Membranous process of mandible present (Figs. 17 and 21, MP). Lateral bristles of mandible four (LBr). Maxilla triangular in shape, with a maxillary brush (Fig. 26, MxB). Mentum with no teeth at the meso-cephalic region (Fig. 30). Paraglossa with 15 teeth, slightly sclerotized and lightly pigmented (Fig. 34) ..... **First instar**

2. Mandibular arms absent 3

2a. Mandibular arms present 4

3. Head about 0.670 mm. in width. Serrated cephalic tooth of mandible with three serrations. Serrated caudal tooth of mandible also with three serrations (Figs. 16 and 20, VDt). Maxillary apodeme poorly developed (Fig. 25, MxAp). Microspines on latero-cephalic margin, few (MSp). Mentum with four or five teeth at the meso-cephalic region (Fig. 29,Th). Paraglossa lightly sclerotized with 17 teeth (Fig. 33) ..... **Second instar**

3a. Head about 1.071 mm. in width. Serrated caudal tooth of mandible with four serrations (Figs. 15 and 19, VDt). Maxillary apodeme fairly developed (Fig. 24, MxAp). Microspines on latero-cephalic margin of maxilla numerous (MSp). Mentum with five to eight teeth at the meso-cephalic region (Fig. 28, Th). Paraglossa sclerotized and with 17 teeth (Fig. 32)..... **Third instar**

4. Head about 1.907 mm. in width. Serrated cephalic tooth of mandible with four serrations (Figs. 14 and 18, VDt). Serrated caudal tooth of mandible with four serrations also. Maxillary combs large and heavily pigmented (Figs. 22 and 23, MxC). Microspines on latero-cephalic margin of maxilla numerous and pigmented (MSp). Mentum with six to nine teeth at the meso-cephalic region (Fig. 27, Th). Paraglossa heavily sclerotized and pigmented and with 17 teeth (Fig. 31) ..... **Fourth instar**

VIII. ACKNOWLEDGMENTS

The author is deeply indebted to Prof. W.P. Hayes, the Head of the Department of Entomology, at the University of Illinois. I also wish to acknowledge Prof. W.R. Horsfall for providing the material and for advice.

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TOXICITY OF CARBON BISULPHIDE TO *SITOPHILUS GRANARIA* L., *SITOPHILUS ORYZAE* L., *TRIBOLIUM CONFUSUM* DUV., AND *RHIZOPERTHA DOMINICA* FAB., UNDER REDUCED PRESSURE

[*Coleoptera* : *Curculionidae*, *Tenebrionidae*, *and Bostrychidae*]

(with 4 Text-Figures and 2 Tables)

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INTRODUCTION

The economic importance of vacuum fumigation as a method of controlling stored products insects, calls for accurate knowledge concerning the effect of reduced pressure on the toxicity of different fumigants to these insects. SALMOND (1953), EL NAHAL (1953, 1 and 2) and BHAMBHANI (1952), have recently published a series of works on this subject. They presented results of designed experiments, the nature of which provided data necessary to unreveal the complicated situation which arises by using fumigants in combination with reduced pressure.

The writer (1953, 1) has shown that the reduced pressure, when sustained throughout the whole period of fumigation, enhances in different degrees the toxicity of fumigants to the adults of *Calandra* spp. The fumigants used were hydrogen cyanide, ethylene oxide and methyl bromide. Such results emphasize the desirability of investigating other fumigants and other pests to increase our understanding of the biological effects of reduced pressure in fumigation work.

The work discussed in this paper is a comparison between the toxicity of carbon bisulphide to the adults of *Sitophilus granaria*, *S. oryzae*, *Tribolium confusum*,

and *Rhizopertha dominica* under reduced pressure and its toxicity under atmospheric pressure. The vacuum fumigation method used is the one termed by PAGE and others (1953) "The sustained vacuum fumigation method".

MATERIALS AND EXPERIMENTAL METHODS

Material

Sitophilus oryzae weevils were bred on whole grains of Indian corn free from any old infestation and containing 13% moisture. *S. granaria* and *Rhizopertha dominica* were bred on wheat of about 14% moisture content. For *Tribolium confusum*, whole wheat flour that had been passed through a 50-mesh sieve was used. All insects were reared in an incubator running at 28 ± 1°C. and about 70% relative humidity.

The technique used for obtaining adults of these insects of about the same age was that described by SUN (1947). Throughout the whole work, adults of about 4-5 weeks old were used.

Adults for treatment were confined, together with a strip of filter paper for them to crawl on, in muslin covered glass tubes of about 1/2 inch diameter. Each tube contained 40 adults of any one species.

Fumigant

The sample of carbon bisulphide used in this work was stated to be not less than 98% pure. A sufficient amount of the material was kept in a pyrex glass bottle for use throughout the experiments.

Experimental procedure

Pyrex aspirators of about 10 litres capacity were used as fumigation chambers. The two openings in each aspirator were stoppered with rubber bungs thoroughly rapped with two layers of tin paper to prevent direct contract between fumigant and rubber.

The gas was released into the closed fumigation chamber by breaking an ampoule containing a weighed amount of the fumigant. The technique of making and filling these ampoules is described by LUBATTI (1935) and TURTLE (1941).

In the atmospheric fumigation method, the glass tubes containing the insects were placed in the fumigation chamber, the glass ampoule containing the required dose of the fumigant was also placed in the centre of the bottom of the chamber, and the chamber was stoppered. The glass ampoule was then broken by the aid of a glass rod inserted through the top stopper.

In the sustained vacuum fumigation method, the pressure in the chamber was reduced to 4 cm. of mercury before breaking the ampoule. A glass tap was inserted through the lower stopper to enable connection with the vacuum pump.

To assist distribution of the fumigant in the chamber, the glass rod inserted through the top stopper, and to which a disk of tin paper was attached, was moved up and down so many times at the beginning and at occasional intervals during the exposure period. The period of exposure was considered to begin when the ampoule was broken and to end when the chamber was opened and the tubes of insects withdrawn. In the vacuum method, air was admitted in the chamber up to atmospheric pressure just before opening.

All experiments were carried out at 28°C. by keeping the fumigation chambers throughout the whole period of exposure in an incubator running at this temperature.

After withdrawing the tubes of insects from the chambers at the end of each experiment, the insects were transferred to ordinary sample tubes, given the appropriate food and then incubated for five days under the same conditions of breeding. Mortality was then determined by spreading the insects on a white enamel tray and warming them under a lamp.

Experimental design

The experiments were planned to provide concentration mortality regression lines for each species at two periods of exposure, 2 and 4 hours under atmospheric as well as under reduced pressure. These two periods of exposure were chosen because the exposure period commonly followed in vacuum fumigation work usually falls in this range. An absolute pressure of 4 cm. of mercury was standardized in all vacuum fumigation experiments. This pressure was also adopted because it is the usual pressure used in industrial work. The aim of this work is to study the methods actually used rather than the effect of different pressures, which of course is worth of investigation separately.

Preliminary experiments were necessary to determine the dosage range giving mortalities between 20 and 90% for each species separately. Then a series of experiments were carried out for each species to cover a number of points within this range of mortality. The concentration of fumigant was taken as the nominal concentration, derived from the dose and the capacity of the chamber, assuming that losses by absorption were very small. The range of doses studied throughout the whole work was between 1 mg./l and 62 mg./l. It was thought advisable not to use doses less than 1 mg./l. since such low concentration is not usually practised in industry especially in vacuum fumigation work.

Interpretation of data

The percentage responses for each batch of insects, after correction for any control responses using ABBOT's formula, were converted into their probits (FISHER, 1948). Dozage mortality lines, whenever possible, were plotted for probit logarithmic transformations for each species of insects. Then the 50% lethal doses (LD50's) were estimated by the probit method of analysis. The slopes of the probit lines are also recorded.

Results

The responses of the different species used are plotted graphically in Figures 1-4, and the essential statistics of each regression line are set in Table I. Each point

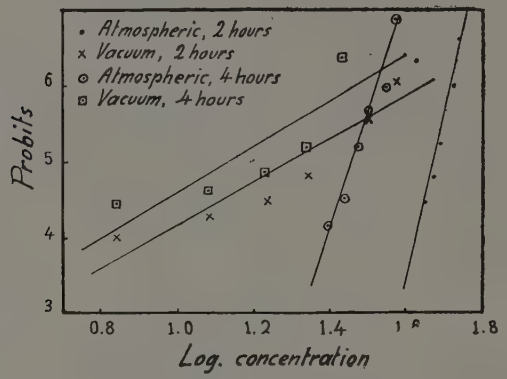

FIG 1 : Dose-kill regression lines for *Sitophilus granaria* L.

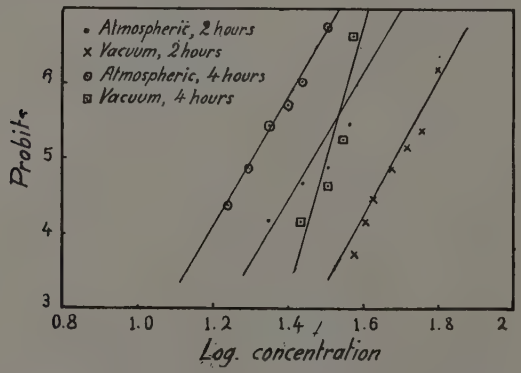

FIG. 2 : Dose-kill regression lines for *Rhizopertha dominica* Fab.

represented on the Graphs is the mean of four determinations. The calculated 50% lethal doses (LD50's) are also recorded in Table I. The mortalities of *Sitophilus oryzae* and *Tribolium confusum* in the vacuum fumigation method were very high even with the lowest dose used, 1 gm./l., especially when the period of exposure was 4 hours. In the case of these two species, therefore, enough data were not provided for obtaining regression lines under reduced pressure.

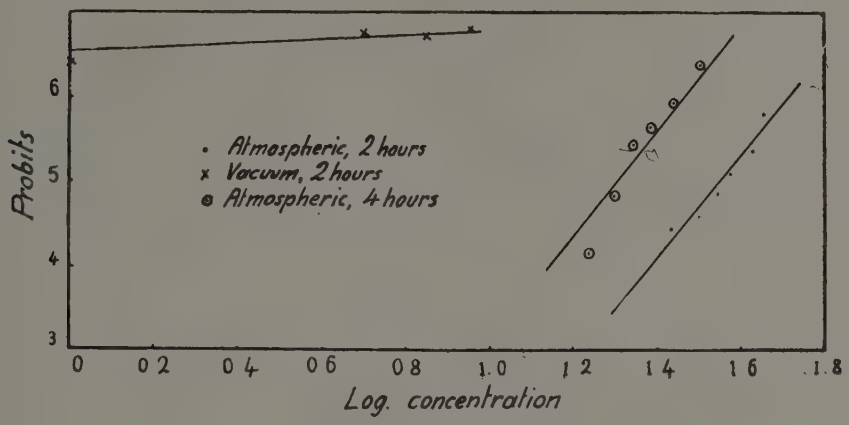

FIG. 3 : Dose-kill regression lines for *Tribolium confusum* Duv.

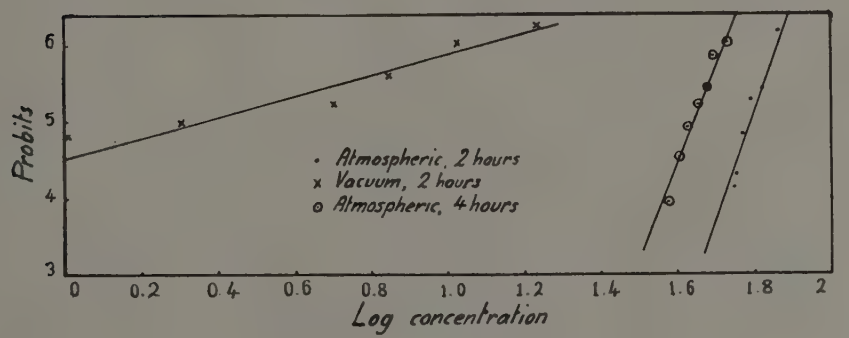

FIG. 4 : Dose-kill regression lines for *Sitophilus oryzae* L.

The results show that while *Sitophilus granaria*, *S. oryzae*, and *Tribolium confusum*, are much more susceptible to the fumigant under reduced pressure than under atmospheric pressure, *Rhizopertha dominica* is more resistant under similar conditions.

The results show further that the influence of reduced pressure in increasing the toxicity of the fumigant to the first three species is different. The greatest in enhancement of toxicity occurs with *Sitophilus oryzae* and *Tribolium confusum*. In the case of *T. confusum*, e.g. a 2 hour 50% kill under atmospheric conditions, required more than 29 times the dosage necessary under reduced pressure (4 cm. of mercury). In the case of *Sitophilus granaria*, however, the 2 hours 50% kill dosage was only slightly more than 2 times as much as that necessary under the same reduced pressure.

TABLE I

Regression equations and 50% kill doses

Period of experiment	Species	Regression equation Y = Probits X = LOG. Concentration	Degrees of freedom	t	Probability P > 0.05* P < 0.05** P < 0.05***	50% kill dose mg. l
		ATMOSPHERIC				
Two hours	*S. granaria*	Y = 22.8444 × — 33.2197	4	10.47	****	47.11
	S. oryzae	Y = 6.3100 × — 47.4400	4	7.39	***	34.95
	T. confusum	Y = 5.2189 × — 4.2139	4	2.35	*	58.13
	R. dominica	Y = 7.9004 × — 6.6332	3	4.38	**	29.68
		SUSTAINED VACUUM				
	S. granaria	Y = 2.6463 × + 1.4971	5	5.52	***	21.07
	T. confusum	Y = 1.2049 × + 4.6557	4	7.33	***	1.93
	R. dominica	Y = 1.6800 × + 3.0362	5	3.36	**	58.09
		ATMOSPHERIC				
Four hours	*S. granaria*	Y = 14.5022 × — 16.1155	4	8.46	***	28.58
	S. oryzae	Y = 7.9897 × — 5.4835	4	10.97	***	20.51
	T. confusum	Y = 13.7278 × — 17.4305	5	20.14	***	43.04
	R. dominica	Y = 8.4683 × — 6.0267	4	28.55	***	20.04
		SUSTAINED VACUUM				
	S. granaria	Y = 2.7804 × + 1.8333	3	2.62	*	13.77
	R. dominica	Y = 16.3173 × — 19.4789	2	2.82	*	31.63

The number of observations for each regression equation is equal to the number of degrees freedom plus 2.

Each observation is the average of 4 replicates.

In order to throw some light on the above results, it was thought useful to study the relative resistance of the four insects to reduced pressure alone. An additional series of experiments under the same conditions of the vacuum fumigation experiments but without adding fumigant were carried out. The results are shown in Table II. Each one of the figures in this Table is the mean of at least 6 observations. The results of this study indicate that *Rhizopertha dominica* is very much more resistant to reduced pressure than the other three species. *Tribolium confusum* comes in between *S. granaria* and *S. oryzae*. It should be mentioned here that no attempts were made to condition the relative humidity of the atmosphere of the fumigation chamber. This atmosphere, after reducing the pressure to such a low level as 4 cm. of mercury, was supposed to be dry, a case which increases the influence of the reduced pressure in killing insects (BAMBHANI, 1952; EL NAHAL, 1953, 2).

TABLE II

Mean percentage mortality of the four species at reduced temperature, with increasing period of exposure (pressure 4 c. mer.; temperature 28°C.; nearly dry atmosphere).

Exposure period in hours	Percentage mortality of :			
	S. oryzae	*T. confusum*	*S. granaria*	*R. dominica*
1	40	6	0	0
2	62	20	10	0
3	—	83	45	0
4	95	100	82	4
6	100	100	100	18
8				33
15.5				67
18				78
20				92
24				100

Each figure is the mean of at least 6 observations

The comparison between the two sets of data, i.e. the data of the fumigation experiments and the data of the experiments under reduced pressure alone, indicates that the resistance of the four species studied to carbon bisulphide under reduced pressure follow their order of resistance to the reduced pressure alone. Because there is a wide difference between the order of resistance of *Rhizopertha dominica* and the other three species to the reduced pressure, this insect required higher doses at reduced pressure than at atomospheric pressure. The 2 and 4 hours 50% kill doses for this species under reduced pressure are 58.09 and 31.63 mg./l., respectively, whereas they are 29.68 and 20.04 mg./l. under atmospheric pressure.

Discussion

The results of the experiments reported above extend and confirm the results of SALMOND (1953) and EL NAHAL (1953) in that the fumigants are more toxic to the insects under reduced pressure than under atmospheric pressure. But this is not always the case, because, as has been mentioned above, *Rhizopertha dominica* was found to be more resistant to the fumigant under reduced pressure than under atmospheric pressure. When the resistance of the four species to the reduced pressure alone was examined, this species showed a wide difference in the order of its resistance.

From a theoretical point of view some reasons for these findings must be sought. In the absence of detailed knowledge of the physiological changes that occur during vacuum fumigation, only general considerations can be sought.

Because the toxicity of a fumigant depends mainly, if not completely, upon the rate of respiration, it might be that the rate of respiration of *Rhizopertha dominica* at the level of reduced pressure studied in this work (4 cm. mer.) is quite low. The findings of MOORE and CARPENTER (1938) and BAMBHANI (1953) support this suggestion. The first writers, examining the effect of HCN on several species of insects under different air pressures, observed a sharp decrease of mortality by the fumigant when some species of insects are exposed to extremely low pressures. They referred this to some mechanical change due to low pressure such as the closing of the spiracles and collapse of trachea. The period of exposure they used was only 10 minutes, which is relatively very short. The second writer found that the water loss due to reduced pressure from *Sitophilus* spp. was very much less at such low pressures as 1-2 mm. mercury than at 2 cm. mercury absolute pressure.

These findings together indicate that there is some sort of respiratory behaviour of the insects at low pressures which varies from one species to another, and accordingly, the different species do vary in the order of their response to different fumigants in vacuum fumigation. This also might be a means of "protective stupefaction" (see GRAY and KIRKPATRICK,, 1929, and LINDIGREN, 1938) due to the ability of some species of insects, represented in this work by *Rhizopertha dominica*, to adapt themselves to resist severe circumstances when first exposed to less severe conditions. In the case of vacuum fumigation, the insects are exposed first to low pressure alone then to low pressure in combination with the poisonous gas.

SUMMARY

Adults of *Sitophilus granaria*, *S. oryzae*, *Tribolium confusum*, and *Rhizopertha dominica* have been fumigated with carbon bisulphide by the sustained vacuum fumigation and atmospheric fumigation methods in glass chambers of about 10 litres capacity. One level of pressure reduction, 4 cm. of mercury absolute pressure, was standardised in the vacuum fumigation experiments. Other factors were : periods of exposure 2 and 4 hours, temperature 28°C., age of insects 4-5 weeks and criterion of response being death. Regression mortality dose lines and regression equations were made for each species, and the 50% kill doses were calculated. The order of resistance of the four species to the reduced pressure alone (4 cm. of mer.) was also examined under the same conditions of the experiments.

Sustained pressure reduction increased the toxicity of the fumigant to the first three species in different degrees. *Sitophilus oryzae* was the most affected and *S. granaria* was the least affected. The order of this effect followed the same order of the effect of reduced pressure alone on the three species. *Rhizopertha dominica* was found to be more resistant to the fumigant under reduced pressure than under atmospheric pressure. This species also showed a relatively very wide difference in its resistance to the reduced pressure alone. This behaviour was attributed to some

sort of respiratory behaviour under reduced pressure, or some sort of protective stupefaction, the nature of which is not studied in this work.

ACKNOWLEDGMENT

This work was performed at the Department of Plant Protection at the Faculty of Agriculture, Cairo University. The author is greatly indetbed to Prof. Dr. AHMED SALEM HASSAN, the Head of the Department, for reading the manuscript and for his valuable criticism.

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DIRECT OBSERVATION METHOD FOR MEASURING THE SPIRACULAR ACTIVITY OF INSECTS

(with 1 Text-Figure)

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INTRODUCTION

It is needless to say, save for the importance of the spiracular (stigmatic) regulatory mechanism in insects' control and their existence on land, methods for measuring the spiracular activity may not attract attention. Such mechanism is indispensible to insects because it regulates moisture loss, gas exchange and keeps aways dust particles, spray droplets and fumigants. Its absence was the possible limiting factor in the evolution of Onychophora (RAMSAY and MANTON, 1937). The evolution of insects as a group of terrestrial organisms was supposed to be largely facilitated by acquiring such mechanism (HASSAN, 1935). Entry of rotenone dusts into the spiracles of *Melophagus ovinus* increased the rate of its action (WEBB, 1945). ROY and GHOSH (1944) reported that *Chrysomyia megacephala* with their spiracles blocked did not respond as readily as the normal insects to pyrethrum dusts.

This paper is primarily concerned with pointing out the disadvantages of the direct observation method. The effect of CO2 and lindane on the cockroaches' spiracles is also studied by this method. Simply stated, the direct observation method entails the observation of the opening and closing of the spiracles under a bionocular microscope, and manually recording these movements on a revolving drum.

MATERIALS AND METHODS

A total of ten male laboratory reared American roaches were used in this experiment. They were picked up from a roach culture which was fed hydach mixture. Five of the roaches were treated each with 0.015 ml. of 0.13% lindane acetone solution while the other five were untreated. The treated roaches were not used before showing symptoms of toxicity (stage of convulsion).

In order to study the spiracular activity each of these roaches was placedon a slide with its ventral side facing upwards. The roach was tied to the slide by a thread around the neck and the forepart of the abdomen, and was then centered in a binocular field with its left side up.

A set up of revolving drum, lever, automatic time marker, dry batteries and a Reymond key was used in these studies. When the spiracle opened or closed, the circuit was made and broken respectively by manipulating the Reymond key. Only the opening and closing of the left mesothoracic spiracle of each roach were recorded.

The response of the spiracle of each of these roaches to CO2 was tested in the following way. A flow of CO2 was directed on the spiracle until the insect started kicking with its legs. Then, the flow of CO2 was stopped and the spiracle movements were recorded by the direct observation method until the roach returned to its normal condition. The CO2 concentration used in the present work was not determined. However, since an increase in the spiracular activity due to CO2 treatment ensued in almost every case, it follows that direct observation method dilute concentrations were actually used (KITCHEL and HOSKINS, 1935).

RESULTS

The spiracles of the untreated roaches (Fig. 1, A and B) were either closed or opened most of the time, with sporadic sluggish movements at irregularly long periods. Sometimes, when the spiracles were opened or closed they went into fibrillar movements with their valves slightly moving. However, it was difficult to notice whether they were touching each other or not. After treatment with CO_2, the rate of spiracular movements became faster and then returned gradually to normal rate.

The lindane treated roach (Fig. 1 A and B) closed and opened the spiracle at a fast rate which seemed to be in pace with the convulsions of the body. The rate of movements was almost regular, it closed nearly twice in every five seconds and that was far less than that of the spiracular movements in the untreated roach as it moved its legs.

CO_2 widely opened the spiracles which nearly regained their regular rate as the effect of CO_2 weakened. These results clearly showed that the lindane treated roaches respond to CO_2 differently from the normal roaches.

DISCUSSION

Involuntary movements of the paralyzed appendages of the treated roaches and convulsions of their abdominal muscles, partially or entirely, accounted for the increase in spiracular activity The sudden burst of spiracular activity due to the leg kicking of the untreated roach (M in record D) is strongly in favor of the above conclusion. It is then evident that by the direct observation method, the net action

of the neurotoxin on the respiratory centers and spiracular nerves of roaches can not be studied apart from the action of metabolites (presumably produced by leg kicking) on these centers and nerves.

From the above results lindane which is a neurotoxin like DDT (BROWN 1951) induced a definite change in the spiracular activity of the American roach and its response to CO_2. These results conform, in general, with the observation made by BUCK and KEISTER (1949) on the abdominal spiracles of *Photinus pyralis*. By means of the direct observation method it was observed that the above fly permanently opened its spiracles when it was poisoned by DDT. The above authors could not observe the spiracular activity of *Phorima regina* because its spiracles were minute and difficult to observe.

According to these authors, it was doubtful that the increase in moisture loss when the latter insect was treated with DDT was due to paralysis of the neuro-muscular system controlling the spiracles. However, they did not show experimentally whether this increase in moisture loss was due to the increase in metabolism incurred by the insecticide or by its effect on the neuro-muscular mechanism of the spiracles or both. That increase may also be due to the convulsions of body muscles and other body movements induced by DDT.

It may be concluded from the work of the above authors that:

1. — Direct observation method is impractical for small insects.

2. — The effect of the drug per se on the neuro-muscular mechanism of spiracles cannot be separated from the effect of body movements or increase in metabolism on the spiracular activity by that method.

An increase in spiracular activity was clearly noticed on directing the CO_2 flow on the spiracle of the untreated roach. That conforms with results obtained by Kitchel and Hoskins (1935). They pointed out that with 5, 10 and 15% CO_2, the maximum rates of ventialation were 3, 5 and 6 times the normal rate respectively, in air for the Hawiian roach *Nyctobora noctivaga*. By using 20 and 30% mixtures, tremondous initial increase in ventilation was followed by almost immediate decrease particularly with the higher concentration. Undiluted CO_2 caused an immediate decline in ventilation and no evidence of an initial acceleration was found.

The response of the treated and untreated roache's spiracle to CO_2 is definitely different as is shown in Figure 1. It is evident then, that an atmosphere containing CO_2 is not undesirable should the effect of a neurotoxin on the spiracular activity be studied.

The weak points of the direct observation method and its disadvantages are of prime interest in this paper. Briefly, these disadvantages are :

1. — It depends on the alertness of the worker and his quick action to follow and record the spiracular movements.

2. — It is impossible to record the spiracular movements of more than one spiracle at a time. By observing the metathoracic and mesothoracic spiracles simultaneously, it was noticed that they moved at different times and at different rates.

Thus, the recording of the spiracular activity of all spiracles is unavoidable should a comprehensive study on the spiracular activity of the insect is carried out. Apparently, this is time consuming and tedious.

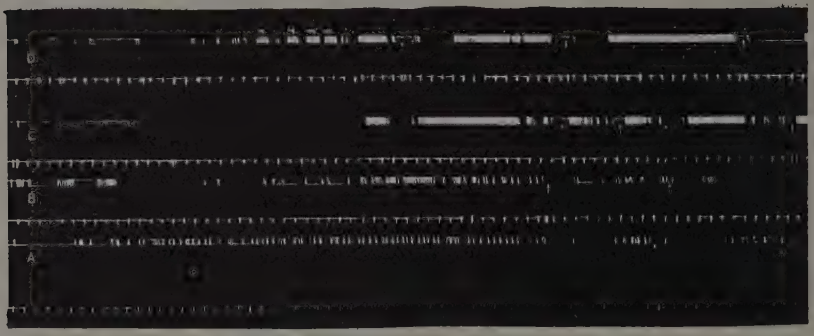

FIG. 1 : Records A-D, made with one roach, each, show the spiracular activity of the left mesothoracic spiracle of the normal roach (untreated), and lindane treated american male roaches. They also show the response of the spiracles to CO_2 and record D also shows the response of the spiracle to body movements. Time is given under each record, and is the same for all of them (5 seconds).

Legends of the records: A and B roaches treated with 0.015 ml. of lindane; C and D = untreated roaches; arrows indicate the treatment of the spiracle with a flow of CO_2; M=the great increase in spiracular activity due to body movement; opening of the spiracle in indicated by the downward deflection of the signal marker.

3. — The rate of movements of one spiracle is liable to variations because the spiracular movement was recorded only after the insect stopped moving and it moved from time to time with different degrees of strength and for varying periods of time. Consequently, the period of closing and opening of the spiracle differed from time to time after the roach stopped moving according to its O_2 need.

4. — The degrees of opening or closing the spiracle can not be recorded by this method; a half opened spiracle will be recorded as a widely opened one. A closed spiracle may leak some gases, especially when it is in slight fibrillar action.

SUMMARY

The effect of lindane on the left mesothoracic spiracle of the American roach was studied by the direct observation method with and without a CO_2 flow hitting the spiracle. The disadvantages of this method pointed out in this paper necessitate finding a substitute for it to measure the spiracular activity of insects.

ACKNOWLEDGMENTS

Thanks are due to Prof. Dr. A.A.G. Hassan, Mr. M.S. El-Zoheiry, Prof. Dr. H.T. Zaazou and Dr. A.L. Deeb for their kind help to further that research in the College of Agriculture, Alexandria University.

Prof. Dr. H.S. Soliman shared in preparing this paper for publication. His remarks to that effect were valuable and illuminating.

My thanks are also due to the Department of Entomology (University of Massachussetts), for providing materials, equipment and technical help for carrying out that experiment.

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THE EFFECT OF CERTAIN INSECTICIDES ON OXYGEN CONSUMPTION OF A MEALYBUG

[*Hemiptera-Homoptera* : *Coccoidea-Pseudococcidae*]

(with 3 Graphs)

by Y. M. EZZAT,
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The work represented in this paper was done at the Department of Zoology, University of Maryland, U.S.America. Gratitude is due to Dr. N. E. PHILLIPS of the same Department, for his encouragement throughout the course of study.

MATERIAL AND TECHNIQUE

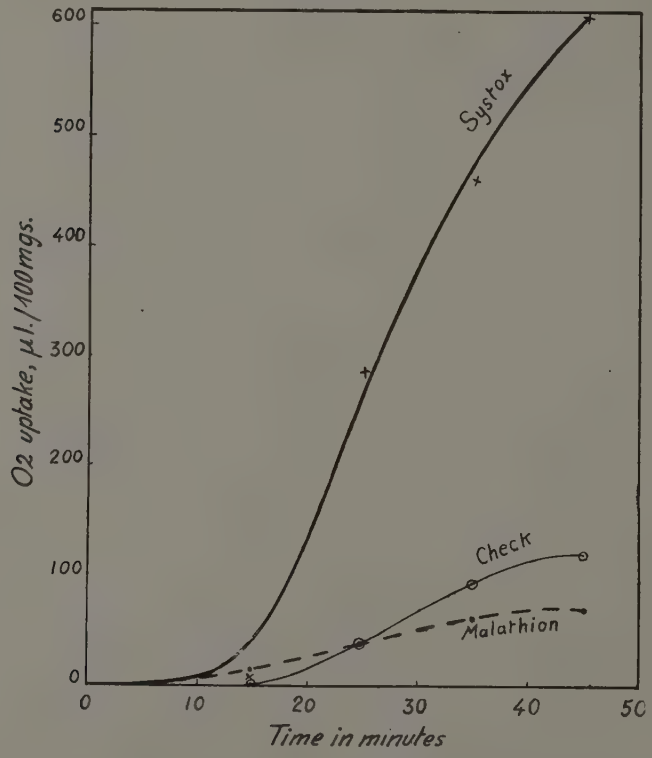
The mealy bug tested was *Pseudococcus maritimus* Ehrhorn. WÓRBURG manometric method was applied to determine the amount of oxygen consumed by bugs treated with Malathion, O, O-dimethyl dithiophosphate of diethylmercapto-succenate; and by bugs feeding on plants treated with Systox, O-(2-(ethylmercapto) ethyl) O, O-diethyl thiophosphate; as well as by bugs raised far of any insecticidal action.

Eight weeks before the experiments, rooted cuttings of *Euonymous* sp. were treated with 50 mls. of water suspensions of Systox at different concentrations. Several pots were devoted for each concentration. The suspensions were applied as soil drenches, and watering of plants, following the treatment, was kept at a minimum to avoid losing the insecticide. Malathion treatment consisted of spraying the plants to run-off with a water emulsion. All instars of the mealy bug were present at the time of application.

The study included two tests. In the first test, three groups of mealy bugs were used : a group from plants treated with Systox containing 0.1 gr. active mater ial

per 100 mls., a group treated with Malathion at the same concentration, and an untreated group as a check. Each group consisted of about 25 bugs, most of which were adults. Total weight of the respective groups ranged from 40 to 70 mgs. This test was run twice, one run for 45 minutes and the other for 60 minutes. Results were

GRAPH I

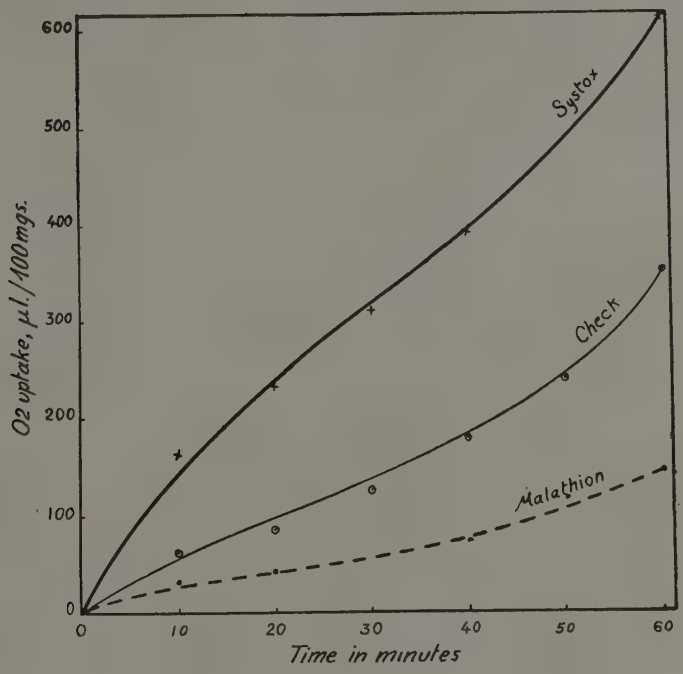


tabulated, and illustrated in Graphs I and II. Each Graph represents the lines of oxygen consumption in micro-liters per 100 mgs. of mealy bugs, at 10 minutes intervals for the period of the respective run except the first interval of GRAPH I which hapenned to be 15 minutes.

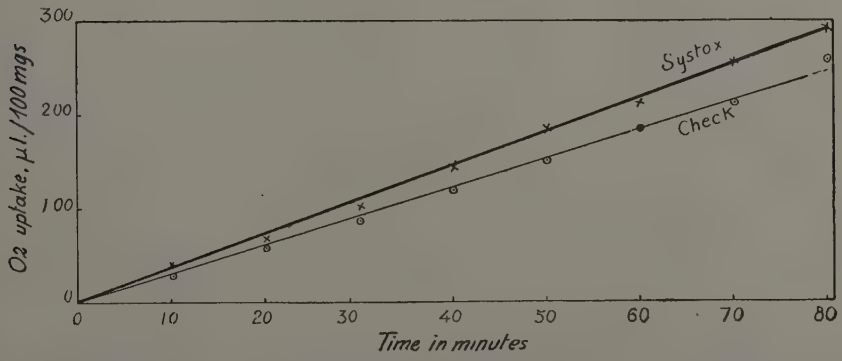
In the second test, three other groups of mealy bugs were examined for oxygen consumption. Two of these groups were taken from plants treated with emulsions of Systox containing 0.005, 0.025, and 0.05 gr. active material per 100 mls., while the third group had not been treated and was used as a check. Each group consisted of 19-23 bugs, including all instars. The total weight per group varied from 20.5 to 23 mgs. Results were tabulated and charted in Graph III. The Graph

shows two lines, one for the average results of the treated bugs and the other for the check. These lines represent the oxygen consumption in mitro-liters per 100 mgs. of bugs at 10 minutes intervals for a period of 80 minutes.

GRAPH II



GRAPH III



In general, it is here considered satisfactory to support the discussion with the graphs only.

RESULTS AND DISCUSSION

Both Graph I and Graph II, representing the first test, express that oxygen consumed by the Systox treated bugs was higher, and that consumed by the Malathion treated bugs was lower than the check. Graph III, representing the second test, still shows some increase in oxygen consumption of the systemic treated bugs. Though this increase is not as startling as that of the first test, it is none the less significant. There are two possible reasons for this obvious reduction in the difference of oxygen consumption occuring in the second test. Firstly, the Systox in this tese had been applied at a much lower dosages, and secondly, the examined bugs included on the whole more immature individuals.

The results of these tests may not be taken as quantitatively valid, but however, qualitative interpretations may be indicative of the increased oxygen consumed by mealy bugs treated with the systemic insecticide Systox. Similar conclusions were approached by Lord, who found that 3, 5-Dinitro-o-cresol, Parathion, Lindane, Pyretherum, Toxaphene, Chlordane, and TEPP, all caused increased oxygen consumption before killing the red flour beetle, *Tribolium castaneum* (Herbst).

On the other hand, discounting the possibility of faulty experimental proprocedure, it appears that Malathion treatment slightly decreased the oxygen consumption.

It is evident that the amount of curvation in Graphs I and II is not great. Meanwhile, it seems that the longer run of the second test obviously straightened Graph III.

SUMMARY

The results of this study may be summarised in the following points :

1. — The plant *Eunymous* sp. absorbs and translocates the systemic insecticide Systox when applied as a soil drench. The effect of such absorption and translocation lasts for about two months after the treatment.

2. — Feeding on plants treated with Systox causes a great increase in oxygen consumption of *Pseudococcus maritimus* Ehrhorn before killing it.

3. — It appears that Malathion treatment slightly decreases the oxygen consumption of the same mealybug.

4. — Tough these results may not be considered as quantitatively accurate, they are qualitatively indicative.

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THE DEVELOPMENT OF A LARVAL LETHAL MUTANT IN *CULEX MOLESTUS* FORSK.

[*Diptera* : *Culicidae*]

(with 4 Text-Figures)

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INTRODUCTION

A species of *Culex molestus* (Forsk.) was found widely distributed in the marshy ponds in the suburbs, south-east of Alexandria. KIRKPATRICK (1925) made a more or less thorough survey on the mosquitoes of Egypt,

Apart from the genetical analysis of the nature of insecticide resistance of mosquitoes among other insects, very little formal genetical work has been done on mosquitoes due to the difficulties involved in keeping handy laboratory stocks. However, MATTINGLY (1955) (quoted from a lecture to the Royal Entomological Society of London), reported to have recovered a few X-ray induced mutations in *Culex molestus*. One of these mutations was sex-linked and caused fusion of the tips of vein 3 and the upper branch of vein 4 with the appearance of a fork cell growing in front of the wing tip. The others were autosomal and affected wing venation or caused reduction of the male palps or antennae.

Spontaneous lethal mutations in recessive condition are normally expected to occur in wild populations. Developmental studies of lethal mutants in mosquitoes are difficult to carry out owing to the fact that a stock heterozygous for a lethal factor which continues to throw the homozygous recessive could not be maintained due to the absence of any inversions which behave as balancers in keeping lethal balanced stocks.

A wild stock of *Culex molestus* was found after several generations of breeding to give an egg raft which yielded almost 25% mortality of fourth instar larvae of which a few may succeed to pupate. These pupae, however, die immediately. This percentage strongly suggested the occurrence of a recessive lethal mutation. Lethal

material was secured in every generation by random mating of a large number of mosquitoes of that egg raft and isolating the deposited egg rafts in separate culture trays.

Inheritance of the lethal factor

The recognition of the sex of the lethal specimens, whether larvae or pupae would seem necessary in determining whether the lethal factor is sex - or autosomal linked. In mosquitoes, females are homogametic and therefore females heterozygous for a sex-linked lethal mated to a normal male would have only half her sons lethal; 25% of the total offspring. Sexing of mosquitoes in the larval condition is not yet known. However, the pupae are easily sexed by the shape of the caudal process which is located ventrad of the base of the paddles. BURGESS (1955), in his attempt to isolate virgins in his hybridization experiments between *Anopheles freeborni* (Aitken) and *A. punctipennis* (Say), found out that this process was horn-like in the male pupae and truncate and notched in the females. A similar sexual dimorphism was also found in several other species of mosquitoes by SHALABY (unpublished). In the present investigation, the 20 lethal pupae studied were found to be males and thus, the lethal factor seems to follow sex-linked inheritance.

Material and rearing

Hatched larvae were raised in finger bowl dishes containing pond water or ordinary tap water to which a suspension of yeast was added. The culture media were changed every two days in order to avoid bacterial infection which results from the putrifaction of the yeast. The emerging pupae were transferred to separate trays and placed in a screened cage which contains two petri-dishes; one contains a piece of cheese cloth soaked in a concentrated solution of sugar to serve as food for the males, and the other contains ordinary tap water for egg laying. It is advisable to lay small pieces of wooden sticks on the surface of the water of the egg laying dish for the females to float on during egg laying.

The blood meals necessary for egg formation were provided either by placing the author's arm in the mosquito cage through a side opening, or by putting a tightly wrapped de-feathered pigeon in the mosquito cage for about four or five hours after sunset. The females of *Culex molestus* oviposit four to six days after the first blood meal. An egg raft contains a number of eggs varying from 150 to 400 eggs. The incubation period is about four days at room temperature.

Lethal phenotype

The lethal effect in the fourth instar larvae is most strongly pronounced in the air tube rudiments and therefore, a prelimenary description of the origin and development of these structures in the wild type seems necessary.

Development of the air tubes in the wild type mosquito larva

The air tube rudiments (Fig. 1, ATR) appear in the late fourth instar larva as transparent oval evaginations of the future pupal hypodermis of the latero-cephalic region of the thorax. Microscopic investigations of sectioned material suggested that they appear in early second instar larvae and grow gradually in size after each moult. The proximal end of each air tube articulates with the future pupal integument by means of two cuticular connections; a mesal connection (Fig. 1, MC) and a caudal connection (Fig. 1, CC).

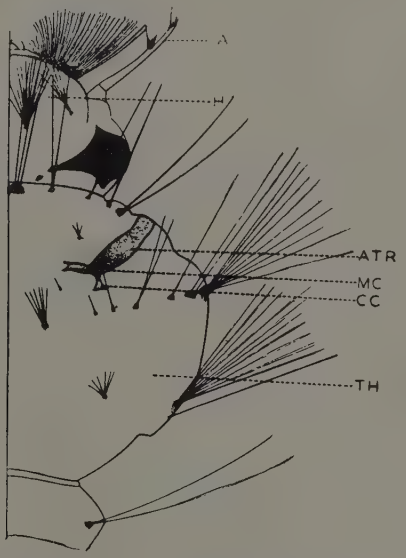

FIG. 1 : Right half of the head and thorax in the late fourth stage larva, showing the "air tube rudiments" (A, antenna; ATR, air tube rudiment; CC, caudal cuticular connection; H, head; MC, mesal cuticular connection; TH; thorax).

In the very late fourth instar, a short while before pupation, the air tube primordia make their first macroscopic appearance due to the sudden heavy pigmentation of their proximal third which, in the larval condition lies latero-cephalad and then continues ventro-mesad as the slightly pigmented remaining part of the air tube rudiment. When the fourth instar larva moults, the air tubes become released and show the characteristic concentration of pigments in their proximal third, while the distal two thirds are slightly pigmented.

Tracheation in the late fourth instar larvae

According to SNODGRASS (1935), the tracheal system of most dipterous larvae and pupae is specialized. The spiracles are present only at the anterior or the posterior end or at both ends. The usual lateral spiracles are either closed, rudimentary or completely absent. In the larva of the mosquito, the respiratory openings are represented only by the posterior spiracles. The main respiratory passages are the dorsal tracheal trunks (Figs. 2 and DTT) 3, and the lateral tracheal trunks (Fig. 2,LTT). The former are conspicuous, relatively large and run lengthwise dorsad, along the entire length of the larval body. The latter are comparatively slender which are formed as connectives between the side tracheal branches of the dorsal trunks.

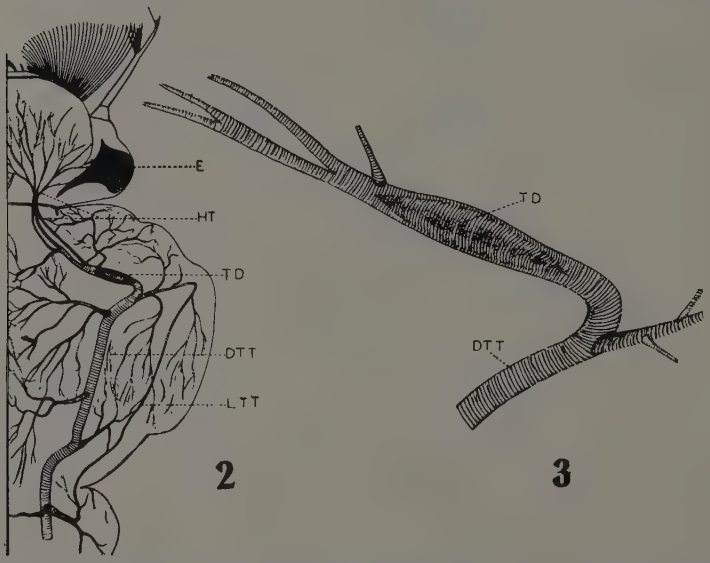

FIG. 2 : Tracheation of the right half of the head and thorax, in the late fourth stage larva (DTT, dorsal tracheal trunk; E, eye; HT, head tracheae; LTT, lateral tracheal trunk; TD, tracheal depression). — FIG. 3 : The tracheal depression under higher magnification (DTT, dorsal treacheal trunk; TD, tracheal depression).

In the larva of mosquito, each dorsal tracheal trunk bends in the region of the metathorax laterad and then extends cephalad until it reaches the prothorax in the region of the future air tubes, where it again bends laterad and then sharply curves meso-cephalad forming a U-shaped structure. A short distance before it enters the head, it divides into three branches which constitute the head tracheae (Fig. 2, HT). It is important to notice that a short distance before the cephalic portion of the

dorsal tracheal trunk branches to the head tracheae, an oval shaped shallow depre s sion is found on its ventral side (Figs. 2 and 3, TD). As shown in the figure, the taenidia in the region of the depression curve dorsad. The degree of curvature of the taenidia increases towards the middle of the tracheal depression, while it decreases at both its ends. It is worthy to note that there is no tracheal connection with the air tube primordia throughout the four larval stages.

Tracheal connection with the air tubes in the pupal stage

The posterior spiracles in the larva become replaced in the pupa by the newly formed anterior dorsal spiracles which are located at the base of the fully developed air tubes (Fig. 4, AT). The dorsal anterior spiracles lead to a very short and stout tracheal passage which continues as an oval shaped depression (Fig. 4, TD) in which the taenidia are curved as to give the false impression of it being composed of two separate tracheal passages. However, during pupal development the central part of this depression gradually disintegrates which results later on, in its separation into two component tracheae as seen in the late pupal stages. The respiratory passages

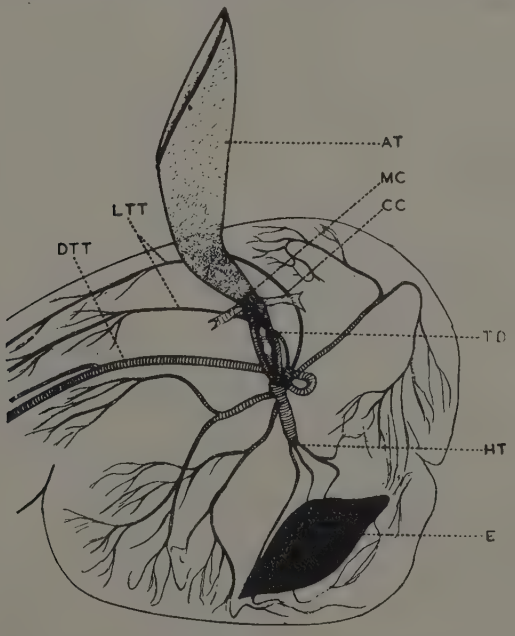

FIG. 4 : Cephalo-thoracic region of an early pupa, showing tracheal connections with the air tube of one side (AT, air tube; CC, caudal cuticular connection; DTT, dorsal tracheal trunk; E, eye; HT, head trachea; LTT, lateral tracheal trunk; MC, mesal cuticular connection; TD, tracheal depression).

of the different parts of the body arise separately from the proximal end of that depression. The dorsal tracheal trunks (Fig. 4, DTT) extend along the dorsal side of the abdomen until they reach the region of the cephalothorax where they extend cephalad, mesad of the tracheal depression and then curve sharply caudad to fuse with its proximal end. The two slender lateral tracheal trunks (Fig. 4, LTT) which also arise from the proximal region of the tracheal depression, curve cephalo-dorsad and then run caudad along the abdomen, laterad of the dorsal tracheal trunks.

The head tracheae (Fig. 4, HT) arise as a single stout and short trachea which extends ventrad towards the head and divides into three relatively slender branches which supply the pupal eye (Fig. 4, E) and the other newly formed organs of the future imaginal head.

If we compare the tracheal system of the fourth instar larva with that of the pupa, we may be able to explain how the former metamorphosed to the latter. It is argued that the dorsal tracheal trunks, during the process of pupation, become connected with the air tubes by certain re-arrangments which may be briefly described as follows : The cephalic portion of the dorsal tracheal trunks which contain the depression is separated from the main trunk proximad and, gets connected to the newly formed respiratory opening at the base of the air tube. The distal end of the remaining part of the dorsal trunk extends cephalad and bends over the cephalic portion of the trunk to connect with it, mesad of the tracheal depression and shortly before it branches to the three head tracheae. The fusion of the head and the thorax in the pupal stage results in a slight change of the course of the tracheae and probably the formation of new minor branches.

The air tube rudiments of the lethal larvae

As it has been early described, the lethal effect is manifest in the air tube rudiment. A heavy pigmentation and complete blackening of the air tube rudiments occur along their entire length. The first, second, third and early fourth instar larvae look morphologically normal. While the very late fourth instar larvae which show the air tube abnormality become suddenly inactive and the wriggling movement becomes obviously reduced. The larvae sometimes sink to the bottom of the tray and can only rise up to the surface with difficulty. Eventually, they die.

In a few cases, some of the defective larvae succeeded to pupate but these pupae died immediately after pupation due to drowning.

DISCUSSION

In *Drosophila melanogaster* where the physiological control of the Entwicklungsmechanik has been largely guided by experiments on lethal mutants, HADORN (1937) has described the lethal giant mutation where late third instar larvae homo-

zygous for it fail to pupate and remain as larvae for a long time after the normal time of puparium-formation. However, a few individuals were observed by HADORN to form pseudo-puparia where development did not progress beyond the stage of puparium-formation. HADORN (1937) was able to induce puparium-formation in lethal giant larvae by ring gland transplant of wild type donors and thus concluded the evidence that the process of pupation is largely dependable on a hormone secreted by the ring gland which was apparently abnormal in the lethal larvae.

The analogy between the pattern of damage of lethal giant larvae and that under investigation, suggests that the latter could be attributed to one or another of the following causes :

In the first place, the lethal factor might have affected an endocrine organ which is responsible for pupation, in which case the abnormality of the air tubes characteristic of the lethal phene is a secondary effect. This assumption seems difficult to test in the absence of information about the anatomy and histology of the mosquito larva. It is hoped that work along this line will be made in the future. In the second place, the instantaneous death of the larvae after the sudden blackening of the air tube rudiments may lead one to believe that death was due to interference either in the process of re-arrangment by which the air tubes become connected to the dorsal tracheal trunks, or to the failure in the formation of the anterior dorsal spiracles. Since the function of the larval posterior spiracles is handed over to the anterior spiracles of the pupa, one must imagine that the change over must be made as quickly as possible or else the larvae would suffocate and eventually drown. However, further studies on this mutant are now being made.

SUMMARY

1. — A description has been made of the tracheation of the head and thorax of both larvae and pupae of *Culex molestus*.

2. — Each dorsal tracheal trunk possesses a depression a short distance before it ramifies to the head tracheae.

3. — This depression in the pupa becomes separated into two tracheal passages and this is brought about by the gradual disintegration of its central part.

4. — A sex-linked recessive lethal mutation in *Culex molestus* was described. It shows a macroscopic defect in the air tube rudiments of late fourth instar larvae which die shortly before pupation. A few larvae, however, may succeed to pupate but these die immediately after pupation.

5. — It was argued that the lethal factor might have affected an organ of endocrine secretion responsible for pupation or caused an abnormality in the tracheal system during the process of pupation.

ACKNOWLEDGMENTS

The authors wish to thank Dr. ALAN STONE, of the Smithsonian Institution of Washington, for identifying the species described. They also wish to acknowledge Professor M. M. RAMADAN, the head of the Zoology Department, Faculty of Science at Alexandria, for facilities offered during the course of this study.

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THE FOOD PLANT AND THE BIOLOGY OF *LEPTOXYDA LONGISTYLUS* (WIED.) IN EGYPT

[*Diptera* : *Trypanaeidae*]

by A. MAHER ALI, PH. D.,

Department of Insecticides, Ministry of Agriculture.

According to BECKER (1903), BEZZI (1914 and 1915), EFFLATOUN (1924) and MUNRO (1948), *Leptoxyda longistylus* occurs in India, Burma, Senegal, Arabia Abyssinia, Sudan and Egypt, where it is known to feed on *Calotropis procera*, exclusively.

However, EL-ZOHEIRY (1948) stated that this fly, feeding primarily on *Calotropis procera*, has adapted itself to live directly on cucurbits, in Egypt, and recommended that *Calotropis*, growing either wild or in gardens, should be uprooted as a measure of control. AZAB and KIRA (1954) confirmed that *Leptoxyda longistylus* is established in Egypt as a serious pest of cucurbits.

On the other hand, investigations carried out by the present authoron thousands of both *Calotropis* and cucurbit fruits, has proved that *Leptoxyda longistylus* is still specialised on *Calotropis*, while another species, *Dacus ciliatus* Lw. (=*brevistylus*), is confined to cucurbits only. AWADALLAH (1956) came to the same conclusion in Arabia. Furthermore, laboratory breedings confirmed field observations.

As next step, all attempts to breed *Leptoxyda* on cucurbits or *Dacus* on *Calotropis*, were met with absolute failure. To confirm such results, *Calotropis* and cucumbers were planted outdoors at Giza, and when fruits were available hundreds of adults of both *Leptoxyda* and *Dacus* were released at different intervals. The results confirmed the first observations. Thus, it became evident that there is no relation between *Leptoxyda* and the cucurbits, and it can be concluded that the campaign of uprooting *Calotropis* is useless and should not be continued.

Leptoxyda longistylus (Wied.), types of which are preserved in the Berlin Museum, was described from Asswan (Egypt), and redescribed by EFFLATOUN (1924) and MALLOCH (1932). It is actually known from Kharga Oasis (Dr. L. H.)

GOUGH, 12.ix.1917), Kharga and Dakhla Oases, Asswan and Kom-Ombo (EFFLATOUN, January 1923). Its host plant is limited to *Calotropis* existence.

BIOLOGY

The adult flies feed on the nectar of *Calotropis*, or on the honey dew secreted by *Aphis nerii* which usually attacks the plant. They are very active during day time, flying between leaves and flowers of their food plant or other shrubs, especially when there is a decrease of humidity. They avoid heat or direct sun rays, are less active after sunset, and hide at night between flowers and buds of *Calotropis*.

Copulation takes place during day time, between 10 a.m. and 4 p.m. During this act, which lasts from two to two and a half hours, the position of the female wings assume a right angle to the long axis of the body. Through clockwise and counter clockwise movements of its body, the fly pierces the fruit sheath with its ovipositor and lays its eggs within the inner layer of the fruit. More than one puncture is sometimes necessary before the fly finds the convenient spot to deposit its eggs. Egg-laying occurs more than once during the fly life-time, and each time 8 to 65 eggs are deposited. The alkaloid milky juice secreted by the plant seals by itself the holes produced by the fly ovipositor during the egg-laying process. Due probably to the fact that *Calotropis* flowers are scarce in winter, consequently there is a decrease in egg production at that time of the year.

The egg is yellowish-white in colour, crescent-like in shape, and measures 1.4 mm. It hatches within three days.

EFFLATOUN (1927) gave an excellent description of the maggot. Newly born maggots feed directly on the seeds, and as they continue to develop on them the seeds turn into a dark mass mingled with faeces, while the fruit assumes a yellowish green colour, loses its calotropin sap, and tends to open before having reached its complete maturity. At that time the maggots are full-grown, measuring from 0.9 to 1.15 mm. in length, and desert the fruit jumping to pupate into the soil.

Under laboratory conditions the maggot stage lasts three weeks and the pupal stage two weeks.

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A STUDY OF THE NERVOUS SYSTEM AND ASSOCIATED STRUCTURES IN THE HEAD OF *BIBIO MARCI* (L.)

[*Diptera* : *Bibionidae*]

(with 111 Text-Figures)

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CONTENTS

I. Introduction. — II. The morphological changes during the development of the head ganglia. — III. The anatomical changes during the development of the head ganglia. — IV. The association centres in the brain. — V. The compound eyes. — VI. The ocelli. — VII. The pigmented bodies. — VIII. The mouth-parts and the tentorium. — IX. The nerves of the head ganglia. — X. The sympathetic nervous system and the associated structures. — XI. The organ of Palmen. — XII. Phagocytes and fore-gut. — XIII. The fat body. — XIV. Summary and conclusion. — XV. Acknowledgments. — XVI. Abbreviations of Figures.

I. INTRODUCTION

Although the life-history of *Bibio marci* (L.) is fairly well known, the anatomy of its developmental stages has not been worked in detail.

In the following account, an attempt is made to describe the anatomy of the head, with particular reference to the nervous system of the larva, pupa and adult, and to trace the course of the changes which take place during the formation of adult structures and disappearance or modification of larval structures.

There has been a lack of agreement between authors on the homologies of the nerves of the head in higher Diptera, and any study of these in the Nematocera may be expected to be of assistance in resolving such difficulties.

Comparatively, little work has been done on what may be called "pupal embryology" that is to say the study of the development during pre-pupal and pupal

stages of adult organ systems and the elimination at least in part of larval systems. The pupal stage is primarily one of intense developmental activity rather than, as is so a resting stage.

It is for these reasons that this study of the normal development of the nervous system of the head of *Bibio marci* has been carried out, bearing in mind that the nervous system and the endocrine system, the two great systems of integration, meet in the head ganglia which are known to have the over-all control of the development of insects.

Some observations have also been made on the structure of the eyes, particularly in relation to the two regions containing different types of ommatidia that are found in the male, and also on the organ of Palmen, which is well developed in *Bibio marci*.

II. THE MORPHOLOGICAL CHANGES DURING THE DEVELOPMENT OF THE HEAD GANGLIA

The larval head ganglia of *Bibio marci* consist of the brain (the supra-oesophageal ganglion) and the sub-oesophageal ganglion, connected with each other by two well developed circum-oesophageal connectives (crura cerebri). These four structures form the oesophageal canal through which the oesophagus, and the recurrent nerve pass. The brain is bilobed, the two lobes being joined by a short transverse commissure which supplies the sympathetic nervous system with four nerves. These emerge from the centre of the posterior ventral part of the commissure. Each lobe gives off an optic stalk ending in the rudiments of the imaginal eye, an antennal stalk parallel to the optic stalk and ending in the antennal bud, and a labral nerve which has two branches, one joining the base of the frontal ganglion, and the other proceeding to the labrum. The circum-oesophageal connectives join the brain laterally to these nerves, and at the same level as the root of the antennal nerve. They pass round the oesophagus to end in the anterior dorsal part of the sub-oesophageal ganglion; the mandibular nerves lie laterally to them.

Metamorphosis begins at the end of the larval life during the so called prepupal period. The head of the larva is hypognathous, while it is prognathaus in the pupa and in the adult. To prepare for the construction of the imaginal foregut, oesophagus and mouth-parts, the larval head capsule turns upwards relative to the body. Through this movement the imaginal fore-gut takes its permanent position and the frontal ganglion, which was much anterior to the oesophagus in the larva, approaches its dorsal walls. Another movement is the retraction of dorsal region of the head, including the brain and the corpora allata (cardiaca), towards the body. As the sub-oesophageal ganglion does not follow this movement of the dorsal region of the head capsule in being pulled back, it comes to lie further forward so that it is enclosed entirely within the head capsule. The circum-oesophageal

connectives, between the relatively stationary sub-oesophageal ganglion and the moving brain, become shorter and thicker bringing the brain into closer apposition with the sub-oesophageal ganglion. These changes are accompanied by the disintegration of the majority of the head muscles giving space for the growth and movement of the neural structures. The optic lobes, during their growth, extend in the prothorax causing the optic stalk to shift far from the antennal nerve. The transverse commissure, which is very small in sagittal section, less than half the diameter of a corpus allatum, grows rapidly to unite with the two larval lobes to form the imaginal brain. In the pupa and in the adult, the brain and the sub-oesophageal ganglion form a compact mass with a narrow oesophageal canal between them.

The formation of the compact ganglionic mass occurs by the end of the pre-pupal stage. Fibres from the secondary antennal centres, the median bundle, the ocellar tract and the posterior tract of giant fibres combine to form the two circum-oesophageal connectives of the larva, which provide the sub-oesophageal ganglion with fibres, and end in the thoracic centres. During development, and after, the larval neurallamella round the brain, the circum-oesophageal connectives and the sub-oesophageal ganglion has been shed; fibres forming the circum-oesophageal connectives lies just lateral to the oesophagus, and are surrounded only laterally by the cortex of both the sub-oesophageal ganglion and the brain (Fig. 43). In the male, the compact ganglionic mass is complete during the pupal stage. In the very young pupa the central commissure and the circum-oesophageal connectives are still retained, while in the female the imaginal brain appears to be complete by the end of the pre-pupal stage (Figs. 45 and 46).

III. THE ANATOMICAL CHANGES DURING THE DEVELOPMENT OF THE HEAD GANGLIA

The head ganglia are enclosed by a continuous membrane (the neurilemma) and consist of the cortex and a central mass of neuropile (punctsubstanz). In this central mass, groups of fibres from different parts of the brain aggregate to form association centres : the central complex, the mushroom bodies, and the protocerebral bridge.

The nerves and the ganglia of the head capsule are enclosed by a continuous thin membranous neural sheath, the neurilemma, consisting of a thin layer of discrete cells surrounded by the neurallamella as a continuous thin membrane of flattened cells.

During the pre-pupa, the larval neural lamella is shed and phagocytized; and the pupal one as a layer of large chromophobe cells with big nuclei forms from the perineurum. There are a few scattered abnormally large cells in the perineurum of the pupa (Fig. 11); these have giant chromosomes which occupy most of the nuclei.

On entering the head ganglia, the tracheal trunks are surrounded tightly by the neurilemma. Numerous tracheae enter the brain at the pars inter-cerebralis (Fig. 74) and the proto-cerebral bridge regions, in addition to the main tracheal trunks. The main trunks are three on each side : two trunks supply the back of the brain, and one ends in the ventral part of the sub-oesophageal ganglion. There is one giant cell surrounding each of these trunks just before entering the brain (Figs. 11 and 12). The cell is identified by its big nucleus that includes a clear nucleolus and giant chromosomes in permanent pro-phase.

Within the pupal and adult sub-oesophageal ganglion, there are fine tracheoles forming few bundles, which unite in one big bundle before leaving the ganglion at a position frontal and mesal to the labial nerve. The bundle is extended ventrally to end in a tracheal trunk that pass round the tentorium — without entering it — before ending laterally in the ventral air-sac.

Apparently, the cortical cells are the neurones of the head ganglia, while their axons form the punctsubstanz. During development no mitosis were noticed in these cells, and growth took place in the pupa as the result of the striking increase in size of these cells and their axons, though this increase varies in rate between different cells. No phagocytosis was noticed in any stage.

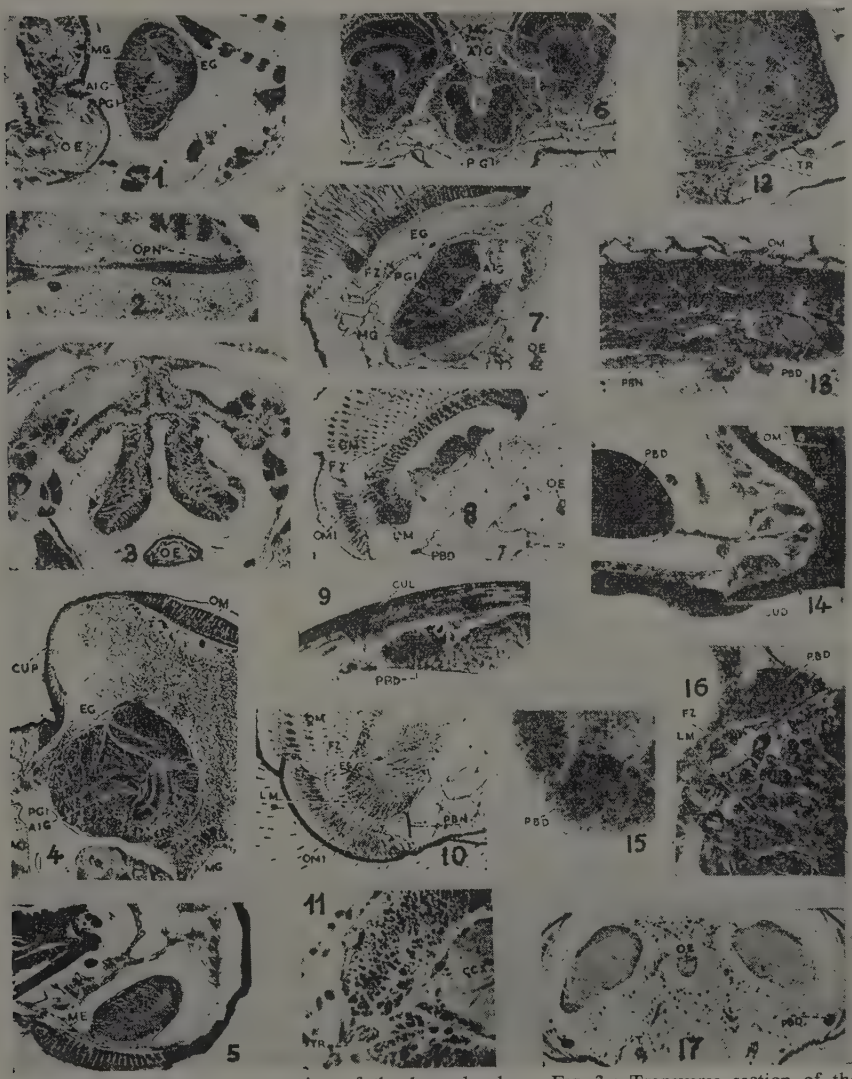
IV. THE ASSOCIATION CENTRES IN THE BRAIN

The central complex forms the most easily distinguished glomerular mass in the proto-cerebrum. It lies in the centre of the brain, limited by the pars inter-cerebralis dorsally, the median bundle frontally, the oesophagus and the central optic commissure ventrally. The dorsal and the median arms of the mushroom bodies surround the central complex (Fig. 30). It is demarcated by nerve tracts and some scattered neuroglia cells (Fig. 40).

The body (Fig. 47) is the largest. It is saucer-shaped (convex-concave), the concave surface being frontal. The body from the front presents a fan-like configuration (Fig. 31) which is due to the coarse fibres coming from the proto-cerebral bridge; these fibres form the ribs of the fan.

The ellipsoid body (Figs. 36, 37, and 40) fits into the concavity of the central body. The ventral tubercles lie directly beneath the two large bodies, the central body and the ellipsoid body (Fig. 37) anterior to the central optic commissure, above the oesophagus and just posterior to, and at the same level with the two ends of the median roots of the mushroom bodies (Fig. 47).

The central complex is connected by fibres with the olfactoria globularis, the pars inter-cerebralis (Figs. 36 and 38), the proto-cerebral bridge and the posterior stalks of the mushroom bodies. Some fibres from the posterior tract of giant fibres (tract associated with the posterior inner glomeruli) run dorsally, turning round the proto-cerebral bridge to end in the central complex.



FIGS. 1-2 : Transverse section of the larva head. — FIG. 3 : Transverse section of the folds of the imaginal compound eyes. — FIG. 4 : Longitudinal section of the head of the early male pupa. — FIG. 5 : Longitudinal horizontal section of an adult female head. — FIG. 6 : Transverse section of the optic lobes of the adult male. — FIG. 7 : Transverse section of the adult male. — FIG. 8 : Transverse section of the head of the adult male. — FIG. 9 : Longitudinal section of the larva head. — FIG. 10 : Transverse section in the male head of a very late pupa. — FIG. 11 : sagittal section of the a pupa brain. — FIG. 12 : Sagittal section of an adult female. — FIG. 13 : Longitudinal section of the pupa. — FIG. 14 : Transverse section of the pigment body in the adult male. — FIG. 15 : Clusters of pigment of an early female pupa. — FIG. 16 : Transverse section of the external glomerules. — FIG. 17 : Transverse section of the head of the adult female.

It is probable that the central complex is important as an association centre, and through its connections with the pars inter-cerebralis, and the corpora cardiaca, it may have something to do with the overall control of the processes of development and the sympatheric nervous system.

In the larva of *Bibio marci*, the central complex is difficult to trace. In the pre-pupa it can be detected as two small glomeruli, each of which is composed of a well difined ventral tubercle and an undifferentiated body, and is located within the arms of the well developed muehroom body of each proto-cerebral lobe. The two glomeruli are connected by a fibrous ommissure within the central commissure of the brain lobes. Early in the pupa when the two lobes unite, and the central commissure shortens, the central complex appears as one large body with the two ventral tubercles. Later, the ellipsoid body becomes larger and clearly distinguishable as a separate structure. At this stage, the neuroglia cells are prominent in the protocerebrum specially round the central complex (Fig. 44).

Two conspicuous large cells can be seen in the central commissure in the pre-pupa, and are also present in the adult as two large cells beneath the central complex and anterior to the central optic commissure (Fig. 32).

The corpora pedunculata are two structures, in the upper part of the protocerebrum, one on each side of the central complex and above the central optic commissure and the oesophagus. Each body consists of three stalks, dorsal, posterior and median, unite at an atero-lateral point.

The posterior stalk, (Figs. 43 and 44) is the largest. It is curved in a ventral direction (Fig. 27) and passes through the punctsubstanz, lateral to the central complex to end dorso-posteriorly in the cellular cortex. The posterior end is greater in breadth than the stalk itself, taking the shape of a glomerulus which is supplied and surrounded by the cellular cortex; but it neither forms calyces, nor is it surrounded by definite groups of globuli cells. In the anterior part of the brain the frontal end of the posterior stalk is greater in breadth in comparison with the stalk itself; it passes in front of the central complex to join the well developed median roots.

The median root from both sides meet in the median line without fusing. This stalk is the shortest and the thickest. It is made of two parallel and closely joined fibrous rods, the anterior one ends in front of the median bundle, while the other one ends in front of the ellipsoid body of the central complex (Fig. 30).

The dorsal stalks (Figs. 26, 27, and 28) are directed dorsally from their connection with the other parts of the corpora pedunculata. They are shorter and thinner than the posterior stalks, but longer than the median roots. Each of the dorsal stalks during its course is curved anteriorly forming an arch with the posterior stalk of the same side. Each stalk terminates in a gradual enlargement ending in the anterior dorsal cortex near the neurilemma and covering the dorsal parts of the brain.

In the pupa, the mushroom bodies are similar to the adults, and are well developed. In the pre-pupa each body is more developed than the central complex.

The three stalks can all be clearly distinguished in the upper part of each of the proto-cerebral lobes. In the full grown larva it is very difficult to distinguish the three stalks of the corpora pedunculata, the whole structure being much less distinct than in the pre-pupa.

In the course of development, the two median roots approach each other in the centre of the transverse commissure while the dorsal and posterior stalks extend up to the postero-dorsal surface of the brain.

The proto-cerebral bridge consists of a pair of structures (Figs. 18 and 72) joined in the mid-line, tying in the cellular cortex in the postero-dorsal area of the pars inter-cerebralis (Figs. 38 and 39); anterior to the ocellar stalks, and posterior and at the same level with the central complex and the posterior stalks of the corpora pedunculata. Each structure has two stalks, median and ventral. The median one, is ellipsoidal in shape, and slightly bent ventrally. The stalk lies horizontally, and in the mid-line of the brain it meets the stalk from the other side. The two stalks are connected with each other by a commissure.

Each stalk at its lateral end turns ventrally at an angle of about 80° to form the ventral stalk, which ends with an enlargement similar to that noticed in the dorsal stalk of the corpora peduculata. There are large cells round the proto-cerebral bridge which are similar to those found in the pars inter-cerebralis. From the end of the two ventral stalks, fine fibres issue ventrally towards the posterior region of the brain.

There is a root or bundle of coarse nerve fibres which put the bridge in contact with other parts of the brain (Fig. 41). The root arises dorsally from each median stalk of the proto-cerebral bridge, and at least the mother cells of some of the nerve fibres are cortical cells surrounding the proto-cerebral bridge posteriorly. Some of the coarse fibres, during their course to the frontal part of the brain, reach the central complex; some fibres turn laterally and run with fibres from the olfactoria globularis during their course to the back of the brain. The centre where the two different fibres meet is lateral to the central complex. The rest of the fibres proceed latero-anteriorly and are divided into two tracts, one ends in the optic tubercle, and the other, turning round the dorsal stalk of corupus pedunculatus, ends in the anterior part of the brain in front of the median bundle where fibres from both sides meet.

The proto-cerebral bridge is quite distinct in the early pupa, tying between the punctsubstanz and the cellular cortex, and the fine fibres emerge from its two ventral ends, and the coarse fibres pass along its two median stalks. In the pre-pupa, the proto-cerebral bridge is not well developed, but the coarse fibres with their mother cells at the posterior end of the brain (the cortical cells) are distinct. The coarse fibres proceed lateralty to the central complex, where they meet fibres from the antennal centres.

The median bundle (Figs. 26 and 27) is a very broad tract marking the front of the brain, lying vertically in the median anterior groove. It appears to arise from

cells in the dorsal cortex, the numerous fine fibres which form the bundle passing, in the median line, to the oesophageal canal where they split into two branches around the oesophegus to go to the sub-oesophageal ganglion.

The proto-cerebral lobes are the remaining parts of the proto-cerebrum which are not characterized by definite glomerular areas. They consist mainly of commissures and connecting tracts between different parts of the brain.

The dorsal posterior commissure of the proto-cerebrum lies at the back of the brain anterior to the transverse parts of the proto-cerebral bridge (Fig 20).

The central commissure (Fig. 21) is a broad commissure level with and behind the ventral tubercle. It receives fibres from different parts of the proto-cerebrum mainly from the anterior optic glomerulus, the antennal centres (Fig. 31) and the proto-cerebral lobes (Fig. 32).

The anterior acessory commissure (Fig. 22) level with and anterior to the ventral tubercles.

V. THE COMPOUND EYES

The compound eyes of adult males are holoptic, those of females being much smaller. The male eye has two well distinct divisions : a prominent postero-superior division, and an anterior one. The former, which is red-brown in colour, covers most of the dorsal surface of the head capsule ; it is limited at its posterior end by the ocelli, and anteriorly it is continuous with the anterior division of the eye. The two superior divisions from both sides meet at the median line of the head. The anterior division is dark-brown in colour, much smaller than the other divisions, and similar to the eyes in the females. The pubescense of the eye is the male sexual character the eyes of the females being bare; the hairs are thin but very numerous, and of extreme and unusual length.

The ommatidia of the female eye (Fig. 5) and those of the anterior division of the male, are pseudocone eyes in which the substance of the pseudocone becomes hard and optically continuous with the cornea so that both together form a biconvex lens; and the nucleated remnants of the pseudocone lie at its apex.

In the superior division incompletely formed ommatidia are found along the median line of the head, and along the border adjacent to the anterior division of the eye; while no such ommatidia are found in the female eyes. The ommatidia in the female eyes, and in the anterior division of the male are best considered as the normal eyes and are of typical Dipteran type, while in the superior division they are different, particularly in their extraordinary elongation and in the position of the cone cells.

Below the ommatidia lies the basement membrane. It is a very thin unicellular layer, perforated for the passage of both the tracheoles supplying the ommatidia and the retinulae. There is much pigment both at the base of the ommatidia and on the surface of the basement membrane. From each ommatidium a retinula, consisting

of seven elongated retinal cells, passes through the basement membrane to the fenestrated zone, where each retinal cell is continuous with a post-retinal axon fibre.

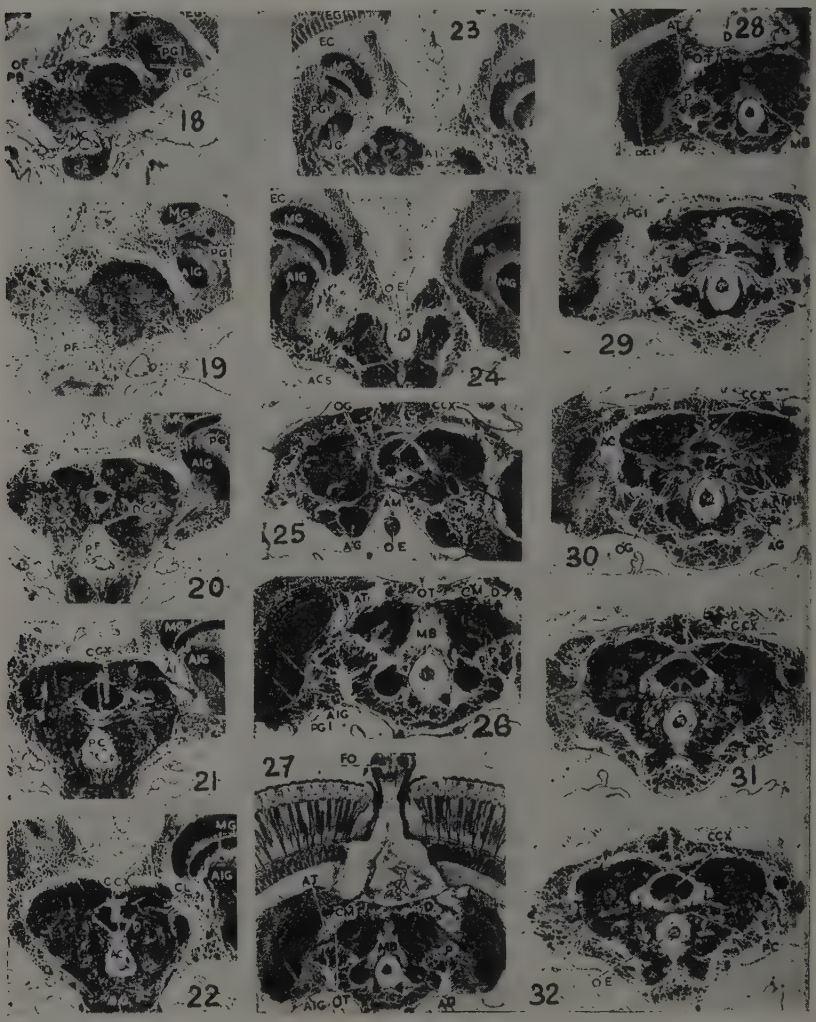
The fenestrated (Fig. 51) zone lies proximal and parallel to the basement membrane. The two are slightly separated from each other by a clear space across which, at fairly regular intervals, there are small bridges composed of the tracheae and the visual fibres from the ommatidia. The bridges and the outer layer of the fenestrated zone "the pigmented layer" contain pigment similar in appearance to the pigment in the basement membrane. The fenestrated zone is highly perforated with the numerous tracheae which supply the zone and spread in all directions. Lying proximal to the large tracheae there are groups of cells identified by their nuclei, each one is large containing scattered chromatin and a distinct nucleolus.

The layer of monopolar neurones (Fig. 7) about four cells in depth, follows the fenestrated zone; the nuclei varying in size (Fig. 16). The axons of these cells proceed through and contribute to the bulk of the external glomerulus, the external chiasma and the middle glomerulus.

The external glomerulus (Figs. 7 and 28) is adjacent to the layer of monopolar neurones and follows the convex shape of the faceted cornea. It is formed of alternate dark and light bands at right angles to the long axis of the glomerulus. The dark bands are the axons of the monopolar neurones located in the fenestrated zone; each two or probably more of which are surrounded by the short visual fibres coming from the ommatidia. Each dark band surrounded by the light short visual fibres form the optic cartridge of CAJAL and SANCHEZ (1915).

In the male, while the ommatidia of both eyes meet dorsally in the mid-line of the head, nevertheless the two external glomeruli are separated from each other leaving a wide dorsal median space between them (Fig. 10). The part of the external glomeruli which is parallel to the superior division of the eye is clearly distinct from the part adjacent to the anterior part. Comparing the two parts, the pigmented layer in the latter contains more pigment, the fenestrated zone contains fewer tracheae and is less perforated, and the layer of monopolar neurones is wider containing about five cellular layers in depth; with their nuclei almost similar in size. The external glomerulus is slightly thinner. The optic cartridges are shorter and more compact, forming a convex shape with shorter radius of curvature, and with its long axis dorso-ventral. A space is left for a wider fenestrated zone that permits the entrance of the main tracheal branches which come from the ventral air sacs at the back of the head, and supply the fenestrated zone (Fig. 27).

The external glomerulus of the female is similar to the glomerulus of the anterior division of the male eye. Having more pigment and fewer tracheae in the fenestrated zone, shorter cones with more curved lenses (the radius of curvature is shorter), and more complex neural elements in the layer of monopolar neurones, may suggest that these eyes are capable of receiving more detailed image (diurnal eyes). It is perhaps possible to suggest that the superior division which contain



FIGS. 18-24 : Serial transverse sections of the head of the adult male. — FIG. 25 : Transverse section of the brain of the adult male. — FIGS. 26-32 : Serial transverse sections of the head of the adult male.

less pigment, more tracheae, longer cones whose lenses each have a longer radius of curvature, may be adapted for receiving images in faint light (nocturnal eye).

The external chiasma (Figs. 18, 23 and 24) is located between the external and the middle glomeruli, and is divided in the male into two separate chiasmata; one for the superior division and another for the anterior one. From each of the two divisions of the external glomerulus, the fibres decussate to enter the opposite side of the middle glomerulus. In the superior division, where the external glomerulus is dorsal, the fibres decussate from the anterior to the posterior of the head and vice versa; that is, fibres arising from the ommatidia in the dorsal region of the eye cross to form the posterior region of the middle glomerulus and so on. The axis of the chiasma lies in a horizontal plane; so that it can only be clearly seen in sagittal section. The fibres which pass from the anterior ommatidia to the posterior part of the middle glomerulus are longer than those arising from the posterior ommatidia to the anterior part of the glomerulus. As the fibres arising from the central ommatidia go directly without decussating to the middle glomerulus they are the shortest fibres in the chiasma.

In the anterior division of the male eye and in the female eye, fibres decussate from right to left and vice versa; the axis of the chiasma lies in a vertical plane and the chiasma is therefore seen in longitudinal horizontal sections. The longest fibres are those arising from the inner ommatidia to the lateral part of the middle glomerulus; the fibres arising from the lateral ommatidia and going mesally to the inner part of the glomerulus are shorter.

The middle glomerulus (Figs. 6, 7, 22, 23, and 24), is proximal and receives fibres from the external chiasma. In the male, the middle glomerulus for the superior and the anterior divisions, form two saucer-shaped bodies with two foci, which are united as one oblong body with its long axis from the anterior to the posterior of the head. The two convex surfaces of the two saucers lie dorso-laterally; parallel to the faceted cornea except for the posterior part of the glomerulus which turns mesally towards the brain leaving a larger space between the brain and the cornea.

The external chiasma, which contain the axons from the ommatidia and from the layer of the monopolar neurones, end by the middle glomerulus. These fibres are at the right angles to the concavo-convex surfaces of the glomeruli. Parallel to these fibres, the axons of the cortical cells surrounding the middle glomerulus, extend through the glomerulus and leave it from the concave surface to form part of the internal chiasma and the internal glomeruli. These two types of fibres are arranged in parallel and adjacent stripes similar to the optic cartridges in the external glomerulus.

There are about eleven concentric stripes which are formed by lateral processes from the transverse fibres.

At the right angles to the transverse fibres, and parallel to and in a plane

between the convex and the concave surface of the glomerulus, there are strong fibres which leave the glomerulus at its anterior part almost at the junction of the two convex surfaces of the two divisions of the glomerulus. These fibres form the serpentine layer which extend posteriorly and medially between the anterior inner glomerulus commissure. It enters the back of the brain and proceeds between the punctsubstanz and the cellular cortex posterior to the ocellar tracts. Just above the oesophageal canal (Fig. 18) it turns to enter the middle glomerulus of the other side. A few fibres from the external chiasma and from the anterior inner glomerulus also contribute in the formation of the commissure. Through this commissure the two middle glomeruli are put in direct contact with each other.

In the female, the glomerulus has one convex surface and receives only one chiasma although the distribution of nerve fibres is similar to the male eye. The body is much less in size, and the transverse fibres, the serpentine layer, and probably the transverse commissure of the middle glomerulus contain fewer fibres; this would suggest that they are less complex than in the male.

There are two inner glomeruli, anterior and posterior, on each side of the brain. They are connected to the middle glomerulus by the inner chiasma. Here again in the male, the lateral surface of the anterior inner glomerulus has two foci which may be related to the two divisions of the eye. The anterior inner glomerulus (Fig. 6) which is larger than the posterior one is saucer-shaped with its concave surface lateral to and in direct and broad contact with proto-cerebral lobe, while the convex surface faces the concavity of the middle glomerulus. This longest axis of the saucer is dorso-ventral and in the male it has two convex surfaces (two arcs) (Figs. 26, 27, and 28), one superior, and one anterior. The two surfaces may be related to the two divisions of the eye, as this body usually has only one convex surface in other insects. The glomerulus is formed of parallel concentric light and dark alternative layers. The first lateral layer is dark and is much thicker in the superior arc, the second layer is light and is represented only in the superior arc; while the third and fourth alternative layers extend in the whole body. The rest of the superior arc appears a loose mass of fibres, while the rest of the anterior one consists of compact alternate layers; they count between 3-4 according to stain reaction. The posterior inner glomerulus, which is not divided into divisions (Figs. 6 and 7), is in the shape of an elongate S, and have seven to nine concentric alternative layers. Its middle layers are loose and provided with tracheae (Figs. 26, 27, and 28). Its long axis is dorso-ventral, posterior and lateral to the anterior inner glomerulus, but not parallel to it. Its ventral extremity almost touches the anterior inner glomerulus. A triangular space is thus formed, bound by the posterior inner glomerulus posteriorly, and the anterior inner glomerulus and the middle glomerulus anteriorly (Fig. 6, right side); this space is occupied by the inner chiasma. The middle glomerulus is connected with both the inner glomeruli by nerve fibres which do not decussate. The anterior inner glomerulus and the posterior inner glomerulus are connected with each other by other nerve fibres which are at right angles to the fibres from the

middle glomerulus. The so called inner chiasma is formed where the nerve fibres passing between the two inner glomeruli and some fibres fromt he middle glomerulus to the posterior inner glomerulus cross fibres from the middle glomerulus to the anterior inner glomerulus, in the triangular space. Fibres from the middle glomerulus collect into a loosely associated bundle before they ramify, without decussating in the two inner glomeruli.

The posterior inner glomerulus is connected with the brain through an important tract, the posterior tract of giant fibres (Figs. 19 and 20), which is the largest tract in the brain after the ocellar tracts. It leaves the glomerulus at its ventral pole to enter the posterior region of the brain at a well tracheated region. The fibres proceed towards the median line, and at the level of the oesophagus form a prominent tract. Here the tract divides; some fibres join with the ocellar tracts which pass ventrally and posteriorly towards the thoracic centre, while other fibres, forming a bundle, turn dorsally, pass round the transverse portion of the proto-cerebral bridge, and end in the central body of the central complex. Probably a few fibres separate at the level of the oesophagus to end directly in the ventral tubercles.

The anterior optic tract (Figs. 26, 27 and 28) emerges from the dorsal median side of the anterior inner glomerulus, and passes towards the median line round the frontal surface of the punctsubstanz of the protocerebral lobe. The tract is divided into two main branches, one ramifies in the proto-cerebral lobe near the posterior stalk of the corpora pedunculata, while the other ends in the optic tubercle. The optic tubercles are two well developed bodies in the dorso-frontal region of the proto-cerebrum just beneath the cellular cortex; they are connected directly with each other by a distinct commissure. In transverse sections an arciform bundle is seen (Fig. 26). This is composed of fibres of the anterior optic tract which end in the optic tubercle, fibres forming the commissure between the optic tubercles, and fibres from the proto-cerebral bridge which ramify in the optic tubercles.

The two anterior inner glomeruli (Fig. 23) are directly connected with each other by this commissure. It arises from the median edge below the anterior optic tract, pass round this edge below the anterior optic tract, round the oesophagus to end in the opposite glomerulus.

In the larva, the imaginal optic lobes occupy most of the proto-cerebrum, and the optic stalk emerges from the anterior part of each lobe. In the full grown larva the external, middle and inner glomeruli can be distinguished within the optic lobe (Fig. 1). The optic stalks are two thick bundles of nerve fibres enclosed by the neurilemma and ending in the two ommatidia imaginal disks which, surrounded by the hypodermis, form two conspicious, narrow, oblong, pigmented areas whose long axes are parallel and mesal to the larval adductor muscles (Fig. 2). In the male pre-pupa the ommatidial disks extend posteriorly almost to the foramen magnum.

The optic stalks are surrounded at their distal ends by large cells with prominent nuclei, numerous tracheae and tracheoles, and nerve elements. These latter,

on entering the ommatidia, form bridges at rather regular intervals. These are the precursors for the fenestrated zone, and the bridges of the visual fibres for the ommatidia.

In the pre-pupa, during the course of development, the optic lobes move into their definitive position. They include the layer of monopolar neurones, the external glomerulus, the external chiasma, and the two inner glomeruli, which are now prominent. The tracts between the glomeruli and the brain are distinguishable. The rudiments of the ommatidia in the eye disk differentiate; the elements become elongate and arranged in groups. As more and more ommatidia are added, the developing eyes become broader, so that by the end of the pre-pupal stage, the compound eyes of the male form two lobes each with two deep grooves and a fifth one in the median part of the head, where the two lobes meet (Fig. 3). These lobes formed are tubular and occupy a considerable part of the head and the prothorax. The anlage of the cornea forms the internal surface of this tube, while the nerve fibres of the two larval optic stalks surround it and end in its external surface which forms the retinula of the eye.

In the pupa (Fig. 4) the two folds separate at the median groove, and the ommatidia of the two compound eyes take their definitive position. The two stalks shorten and their component fibres spread at their distal ends following the developing retinulae. The tracheae, the large cells, and the neural elements of the fenestrated zone are now prominent. The fibres of the larval optic stalk become the visual fibres from the retinulae in the adult, and the bridges they form between the ommatidia and the fenestrated zone become more prominent. The cornea of each eye forms as an extension of the adult cuticle.

It appears that the optic glomeruli and the layer of monopolar neurones originate from the optic lobes, while the visual fibres from the retinula, originate from the optic stalks.

VI. THE OCELLI

Both sexes in the adult have three ocelli arranged in an inverted triangle, two lateral and one median. The lens of each eye is a transparent thin bi-convex part of the cuticle. The corneagen layer is a transparent area of hypodermis under lying and secreting the lens. The retina consists of compact sense cells forming the rhabdomes, which contain no pigment (Fig. 37). In one series of sections a bundle of fibres separates from the retinal ocellar fibres of the median eye, and turns towards the back of the head capsule at right angles to the ocellar nerve stalks (Fig. 36). In other adults this condition was not found.

The numerous short retinal fibres, from the three ocelli are associated with the distal end of the giant ocellar nerve fibres, the ocellar stalk, where they form a ganglionic ocellar centre.

FIGS. 33-35 : Serial sagittal sections of the imaginal brain. — FIGS. 36-37 : Serial sagittal sections of the brain of the male imago. — FIGS. 38-40 : Serial sagittal sections in the adult male. — FIGS. 41-42 : Serial sagittal sections of the imaginal male brain. — FIGS. 43-43 : Serial sagittal sections of an early female pupa. — FIG. 47 : Sagittal section of the head of late female pupa. — FIG. 48 : Sagittal section of the female pupa. — FIG. 49 : Sagittal section of an adult male. — FIG. 50 ; Sagittal section of an adult male (the central complex contains the ellipsoid body (E), and the ventral tubercle (V).

The giant fibres and the ganglion are enclosed in a neurilemma which inturn is in contact both with the hypodermis surrounding the ocelli and the corneagen layer. Some nerve fibres from the occipital nerve end in the hypodermis of this area.

The ocellar stalks enter the brain through the dorsal cellular cortex in a well tracheated region. They separate into two main bundles (Fig. 37), an anterior and a posterior, which form the largest tract in the brain. They are surrounded by cortical cells and few rather big cortical cells can be seen between the fibres. The anterior bundle branches again, the anterior branch following a semi-circular route (Fig. 33) towards the frontal region of the pars inter-cerebralis where it ends, while the posterior branch passes backwards round the transverse portion of the proto-cerebral bridge, to unite with the posterior bundle (Fig. 34). The posterior bundle also divides again into two, one on each side of the brain lying very close to each other. These proceed ventrally posterior to the proto-cerebral bridge (Fig. 35), until they reach a level immediately above the oesophagus. In that region there is some crossing over of fibres between the two sides, and the neurones seem to connect with the anterior tract of giant fibres. Here again some fibres seem to end in the same region while the rest pass to the thoracic nervous centre.

The ocellar glomeruli have not been identified and no connection was noticed between the ocellar tracts and the central complex or the proto-cerebral bridge.

At least some of the nerve cells of the ocellar tracts are located in the cortex at the posterior dorsal region of the proto-cerebral lobes.

The locus of the ocellar fibres has not been identified earlier than the end of the pre-pupal stage. At this stage there is a cluster of large cells with large deeply stained nuclei on the dorsal surface of the commissure between the two lobes of the brain, enclosed within the brain neurilemma. Axons from these cells develop to from the ocellar stalk. The rudiments of the ocellar corneagen and sense cells are prominent at the end of the pre-pupal stage; they are located in the median line of the head of the pupal cuticle between the folds of the compound eyes. Early in the pupal stage the short retinal fibres extend ventrally forming synapses with the ocellar fibres at the ganglionic ocellar centre. The pupal ocellar tracts in the brain are similar to those of the adult.

VII. THE PIGMENTED BODIES

Anatomical investigations show that on each side of the larval head capsule and in the spot where the Cook's eye is located, there is a conical recess in the cuticle, covered with thin bi-convex lens (Fig. 9). The one is provided with a thin neural fibrillar element which ends in a pigmented body. This pigmented body is located near the base of the mandible attached to the proximal end of the ommatidial disks of the compound eye, lateral to the antennal bud. Each body is oval in shape with its surface deeply coated with black pigments.

This organ is retained throughout the life of the insect (Figs. 8 and 17), and some differentiation is observed during the pre-pupal stage. It always remains independent of the ommatidial disks. In the late pre-pupa, when the head capsule including the larval eye is separated from the pupal cuticle, the cells of the pigmented body lie just underneath the pupal cuticle (Fig. 15) and attached to the differentiating ommatidia.

In the pupa (Fig. 13), when the optic stalks become the visual fibres supplying the ommatidia, a special branch of fibres which is still enclosed by the neurilemma coating the optic lobes, can be distinguished which separates to end in the pigmented body at one of its poles. This fibre is thicker, larger, and is more highly pigmented than other visual fibres. It lies at the edge of the fenestrated zone, and turns laterally when it enters the pigmented body (Fig. 10).

When the imaginal cuticle forms and the residual pupal cuticle is separated from the hypodermis, the pigmented body remains distinct and separated from the hypodermis; the only connection being through some loose pyriform cells, which in the adult form a compact nerve, emerging from the other pole of the pigmented body to end in the hypodermis (Fig. 14). The nerve and the area of the hypodermis innervated by it are also deeply pigmented. These lie below the compound eye as the extreme anterior end and at the junction of the cornea of the compound eye and the ventral cuticle of the head. In the male the frontal part of the anterior division of the compound eye is lateral to the pigmented body. The ventral cuticle forms a chitinous ingrowth (which turns inwards) forming an elongated pocket which isolates the pigmented body and its nerve from the compound eye (Fig. 14).

The outer-most layer of the compound eye is the fenestrated zone which contains pigment and tracheae. The lateral edges of the eyes formed by the fenestrated zone and the layer of monopolar neurones is extended outwards and lateral to the outer-most ommatidia of the eye. Each edge forms a single layer of squamous cells which turns round the chitinous ingrowth to join the pigmented hypodermis innervated by the pigmented body nerve. Also, and without exception, all the nerves of the head ganglia have compounds which end in the hypodermis of the head capsule and the neck region, through fine cutaneous neural branches. What the role of the hypodermis is in the transmission of nerve conduction is still unknown, but it seems that the hypodermis has some importance in that respect.

As has been pointed out before, the pigmented body is also connected with the imaginal optic lobe by a special nerve which ends in the external glomerulus (Fig. 10). It is clear therefore that any impulses in this fibre must reach the brain through the optic centres.

The pigment body (Fig. 16) increases in size in the pupa, rapidly reaching its maximum size in the adult. In material stained with Gomori most of the pigment is removed, and the individual cells appear to have large deeply staining nuclei. The cells form a sac, enclosing a globular undifferentiated mass which is penetrated

by fine tracheoles; but no sign of secretion is noticed. The histology is similar in both sexes, in the pupa and in the adult.

The larvae of *Bibio marci* are negatively phototropic. The pigmented bodies may be interpreted as photo-receptor organs for transmission of light. It seems that they are functional in the larval, pupal and the adult stages, since they continue to grow during the pupal stage, and they retain the maximum size in the adult. Their additional connections with the imaginal optic lobes through the visual fibres suggests that these organs may be functional in the adult.

The antennal nerves are mixed nerves, containing fine sensory fibres which supply the well developed Johnson's organ in the pedicullus of each antenna and motor fibres supplying the muscles which control the movement of the antennae. In each antennal nerve two motor nerves pass to the antennal muscles within the head, while others pass to the flexor and extensor of the flagellum which are inserted in the scape of the antenna.

The coarse fibres seem to be more concentrated in the central core of the nerve, while the fine fibres are scattered through the nerve. A nerve arises from the upper side of each antennal nerve a short distance before the latter enters the antenna. This is the tegumentary nerve which runs dorsally to the top of the head, where it bifurcates into two branches which branch out again before they end in arborizations in the fenestrated zone of the compound eyes (Fig. 50). This nerve can be traced in the pre-pupal stage where the antennal nerve itself ends in the antennal bud.

As the fenestrated zone is connected with the hypodermis of the head it seems that the tegumentary nerve ends in a common tissue, the hypodermis.

The tegumentary nerve contains coarse and fine fibres which may indicate that it is a mixed nerve. The fenestrated zone contains "a complex neural tissue" in which the branches of the tegumentary nerve take part. Whether the movements of pigments is controlled by these neural elements, by neuro-secretion, or by both, it is not known.

The antennal centres are represented by a pair of large glomerular masses. The antennal glomeruli lie on each side of the oesophageal canal, the dorsal surface of each touching the ventral part of the central complex. Each glomerulus is composed of a group of spheres, slightly different in shape and size, which in frontal view are botryliform (Fig. 27). The inner surfaces of the spheres adjacent to the brain mass (punctsubstanz) are continuous. There are large cortical cells surrounding the glomeruli. The greater part of the two glomeruli lies in front of the brain mass, but the cortical cells, which are generally larger than the rest of the cellular cortex, fill up the grooves thus created so that not more than two swellings are noticeable in the intact brain (Figs. 33 and 34). The antennal nerves enter the brain at right angles to the median bundles at the level of the oesophageal canal and latero-ventral to the antennal glomeruli. When the antennal nerves enter the brain (Fig. 49), the fine fibres fan out dorsally to enter and contribute to the glomeruli. The coarse fibres of each antennal nerve pass the glomerulus latero-ventrally without entering it,

to form a secondary antennal centre from which some fibres turn dorsally to contribute to the formation of the central commissure of the proto-cerebrum. Others pass ventrally into the ventral cerebral region, though the present material does not show a clear formation (Fig. 24) of a commissure for the antennal centres beneath the oesophagus. The rest of the fibres pass to the sub-oesophageal ganglion to end in the prothoracic ganglion.

The two glomeruli are connected directly with each other and also with different parts of the brain through several tracts. They are connected directly with each other by two commissures, one of fine fibres (Fig. 29) and the other of coarse (Fig. 30), which pass over the oesophageal canal at the level of the ventral tubercle and are just posterior and perpendicular to the median bundles, beneath and parallel to the median stalk. The commissure of fine fibres is anterior and dorsal to that for coarse. From each glomerulus fibres cross to the other side of the brain to end in the proto-cerebral lobe (Fig. 25). A very prominent tract, the olfactaria globularis (Fig. 25), emerges medially from the posterior part of each glomerulus and on its course towards the back of the brain (Fig. 41) it is in contact with the central complex, the fibres from the proto-cerebral bridge, and the posterior end of the posterior stalk of the corpus pedunculatum. It ends at the back of the proto-cerebral lobe below the proto-cerebral bridge, where some cortical cells from that region seem to be the cell bodies of these fibres (Fig. 48). Another large tract of coarse fibres emerges from each glomerulus laterally; they turn upwards in a semi-circular path to end with their fibres surrounding the anterior ends of the post rior stalks of the corpora pedunculata.

VIII. THE MOUTH PARTS AND THE TENTORIUM

If it is assumed that the insertions of the muscles are always constant and never shift their morphological relations, the lacinia can be recognised by the insersion of the muscles of the stipital and cranial flexor, and the galea by the insertion of the stipital flexor only. The cranial flexor of the lacinia is always retained and is important in identifying the single maxillary lobe when one of the two is absent. On these grounds it is considered here that this lobe is the lacinia, and that the galea has either disappeared or become fused with the stipes.

In the adult, the external cuticle of the head includes four invaginations, one pair situated close to the ventral margin of the head capsule latero-ventratty to the antennae; the other at the ventral back of the head ventrally and in front of the foramen magnum. These paired openings are the anterior and posterior tentorial pits the extremities of two hollow rods forming the anterior tentorial arms. Two solid rods which start at the back of the two posterior pits and extend posteriorly to the neck region, form the posterior tentorial arms. Two bundles of tracheales from the head ganglia pass below the anterior tentorial arms, without piercing their walls to end in the ventral air sac.

FIGS. 51-65 : The organ of Palmen (51, longitudinal section of the larva; 52-53, sagittal sections of the larva; 54, oblique section of the larva; 55 and 59, sagittal sections of the pre-pupa; 56 and 60, transverse sections of the pre-pupa; 57, oblique section of the pre-pupa; 58, longitudinal section of the pre-pupa; 61, longitudinal section of a male pupa; 62, sagittal section of a male pupa; 63 and 64, transverse sections of the female pupa; 65, transverse section of the adult male. — FIG. 66 : Sagittal section of the pupa (in the frontal ganglion there are large (G) and small (S) cells). — FIGS. 67 and 68 : Sagittal sections of the pre-pupa of *Bibio hortulanus*. — FIGS. 69 and 70 : Transverse sections in the adult. — FIG. 71 : Sagittal section in the adult. — FIGS. 72 and 73 : Transverse sections in the adult male. — FIG. 74 : Sagittal section in the adult male. — FIGS. 75 and 76 : Longitudinal sections of the corpora allata in *Bibio hortulanus*.

IX. THE NERVES OF THE HEAD GANGLIA

In the adult, five pairs of nerves labro-frontal, mandibular, maxillary, labial and occipital, emerge from the head ganglia and innervate the muscles and sense organs of the head, mouth-parts and the neck.

The labro-frontal nerves arise from the trito-cerebrum. Each nerve divides to form a frontal connective which enters the frontal ganglion, and the labial nerve which bifurcates into an upper and a lower branch, before ending in the labial hypodermis near the tormea. From the lower branch there are very fine nerves one of which ends in a peripheral ganglion in the hypodermis surrounding the postero-ventral part of the pharyngeal pump.

Although the mandibles are wanting, the mandibular nerves still exist. They arise from the sub-oesophageal ganglion, turn laterally and passing beneath the anterior tentorial arm, end in the fenestrated zone of the compound eyes. A fine branch, probably a neural sheath with no nerve fibres, comes out of the mandibular nerve before it turns laterally. This nerve ends in the hypodermis of a membraneous cuticular region which is dorso-mesal to the maxillary palp. The mandibular nerve is the least developed of the head nerves of the adult, where as in the larva it is the most prominent. The mandibular nerve has a cross connective between the lower branch of the labral nerve of the same side.

The maxillary nerves are connected with the mandibular nerves. One of the two maxillary nerves has a branch which runs dorso-laterally and is united with the mandibular nerve of the same side to end in the fenestrated zone. The other maxillary nerve is connected with the mandibular nerve of the same side by a short neural connective. A fine branch, probably a neural sheath only, arises from each maxillary nerve before it enters the maxillary and ends in the hypodermis of a membranous cuticular region, mesal to the maxillary palp.

The labial nerve on entering the labial palp, divides into two main branches which end in the hypodermis with numerous rather large peripheral ganglia similar to the endings of the maxillary nerve in the maxillary palp. The labial nerve gives off two branches before entering the labellum; a fine one, which turns posteriorly towards the neck, and one which innervates the labial muscles.

The occipital nerves arise at the extreme postero-ventral part of the sub-oesophageal ganglion. Each nerve turns downwards and passes round and beneath the posterior tentorial arm, then turns upwards where it eventually divides. One nerve ends in the dorsal neck muscles, the other divides again into a branch which turns mesally and innervates the dorsal oesophageal muscles which control and support the oesophagus in the neck region, and a branch which turns laterally and enters a ganglion. From this ganglion one fine nerve passes laterally to end in the hypodermis close to the posterior margin of the compound eye. Another very fine short nerve ends in the hypodermis of the back of the head. A third turns mesally to end in another ganglion which is situated just above the occipital condyle of the

head capsule. From this ganglion fine nerves issue which end in the hypodermis near the ocellar stalks.

The imaginal mandibular nerve is only recognisable if it is traced through its larval development, and in spite of the breakdown of the larval head-capsule, the nerves are continuous throughout the whole life of the insect.

The labro-frontal nerve issues from the brain mass proximal to the point of emergence of the antennal stalk. It is joined with the mandibular nerve by a well developed connective which is retained throughout the life of the insect. Beyond this connective, a fine branch is given off which turns dorsally to end in the hypodermis of the frontal part of the head-capsule. This nerve then divides into the frontal connectives and the labral nerve which gives off a few fine nerves ending in the labral hypodermis, and ends in the labrum with a prominent peripheral ganglion. The two imaginal branches of the labral nerves can be identified, in the pupa.

Each mandibular nerve is well developed and ends in a prominent ganglion beyond the labral-mandibular connective. Three nerve branches emerge from this ganglion, one ends in the mandible itself and the other two innervate the mandibular muscles. In the pre-pupa, when the mandibular muscles disintegrate, the mandibular nerves may still be identified, but it has not been possible to trace their branches for their whole course. At this stage another branch, proximal to the larval mandibular ganglion (ME) develops; this may be the imaginal branch to the fenestrated zone. The pre-pupa, thus contains both the larval and the imaginal mandibular nerve branches. In the pupa the imaginal branch to the eye is prominent, while some of the larval nerves are probably represented by their neural sheaths. Each of the maxillary nerves ends in the maxillary bud, and the maxillary branch to the eye, and the branch to the hypodermis near the differentiating maxillary bud, are not identified until the pupal stage.

The labial nerves emerge from the latero-ventral part of the sub-oesophageal ganglion and each end shortly in a ganglion. From this ganglion a main nerve divides in the labial sclerites. Another two fine nerves come out from the ganglion and end in the hypodermis. The labial nerves develop in the pupa, so that by the late pupa they have taken on the adult form.

The occipital could not be traced before the late pre-pupa where they appear as fine unbranched nerves passing backwards. Even in the late pupa, they are not well developed.

X. THE SYMPATHETIC NERVOUS SYSTEM AND THE ASSOCIATED STRUCTURES

The corpora allata (Figs. 77-87) are two pyriform structures placed asymmetrically on both sides of and slightly lower than the aorta, above the oesophagus and anterior to both salivary glands and the proventriculus. They are attached laterally to the corpora cardiaca by the corpora-allata-cardiaca nerves. They lie in the prothorax

as in most insects, near the border between the prothorax and the neck region. The positional relationship between the Palmén organ (Figs. 53 and 54), the corpora allata and the point of emergence from the brain of the two pairs of nerves of the corpora cardiaca remain constant from pre-pupa to adult. The posterior region of the proto-cerebral lobes extends backwards, during pupal growth, so as to lie at the same level as the corpora allata but the latter do not migrate.

The corpora allata are close to the corpora cardiaca but not touching, and each is innervated by a short nerve from the corpora cardiaca (Fig. 88), the corpus-allatum-cardiacum nerve. The nervus corpus-allatum-cardiacum (Fig. 89) is intermediate between these two conditions. Tracheae were noticed entering the corpora anteriorly, from where they run, after branching into tracheoles, between cells and probably penetrate cell walls.

The corpora have a well developed neurilemma sheath similar to and continuous with that of the corpora cardiaca and the hypocerebral ganglion. The corpora are always surrounded by a sheath of connective tissue which is common to that of corpora-allata-cardiaca nerves, and the corpora cardiaca. There are two kinds of cells included in the corpora allata : (*a*) a few undifferentiated cells, with large spherical nuclei and little cytoplasm, and (*b*) the supposed secretary cells. These which appear to have a well defined cell membrane vary in size during the different stages, from medium sized to giant cells. The latter are represented by a few central cells which are particularly in evidence in the pre-pupa.

In the full grown larva, during diapause, the cells are compact, without vacoules with rather large nuclei, rich in chromatin material and a prominent central nucleolus. It is probable that the corpora allata are under control during diapause as are other tissues, and that they do not show any sign of secretary activity.

By the end of the larval stage, after emergence from diapause, the chromatin is not concentrating in the centre of the nucleus, and the cytoplasm contains a number of large vacoules. In the pre-pupa the vacoules are still clear but not so large as those of the late larva and fine granules can be seen, especially around the nucleus. The nucleus itself is large, the nucleolus distinct and the chromatin is still scattered. In some preparations (Figs. 75 and 76) the suspected secretion is noticed in the centre of the corpora in the route of fine fibrils and striation. At this stage, the corpora are larger than those in the larva or pupa. Later, and shortly before pupation, the size decreases rapidly, this change being due to a decrease in the size of the cells than in their number; the vacoules decrease until they are almost or totally absent, and the chromatin becomes concentrated in the centre of the nucleus. At this stage, there is difference in size between the corpora allata of different sexes, those of the female being larger. The sexes may be distinguished by the structure of the compound eye rudiments. During the early pupa, the cells are similar to those of the late pre-pupa, but later the corpora increase in size again, the cytoplasm stainly deeply and vacoules reappearing, the nucleus is very large and irregular in outline, occupying most of the cell and surrounded by fine microscopical particles. The nucleolus is clear and

the chromatin is rich and concentrated in the centre. Vacoules are also present in the corpora at early adults, but they are less conspicious than those of the late larva and early pre-pupa. Eventually, the granules round the nucleus become clear, the vacoules increase.

The corpora allata are similar in appearance during the late pre-pupa and the early pupa (just before and just after ecdysis); they are small in size, without vacoules, and the chromatin is concentrated in the middle of the nucleus. Material from before and after this stage shows inverse parallel development. These changes are : a tendency for the whole organ to increase in size, through the increase of the size of the cells and the volume and number of vacoules; the dispersion of the chromatin in the nucleus; and the appearance of cytoplasmic granules specially around the nucleus. These features may be considered to be indicative of active secretion to the organ.

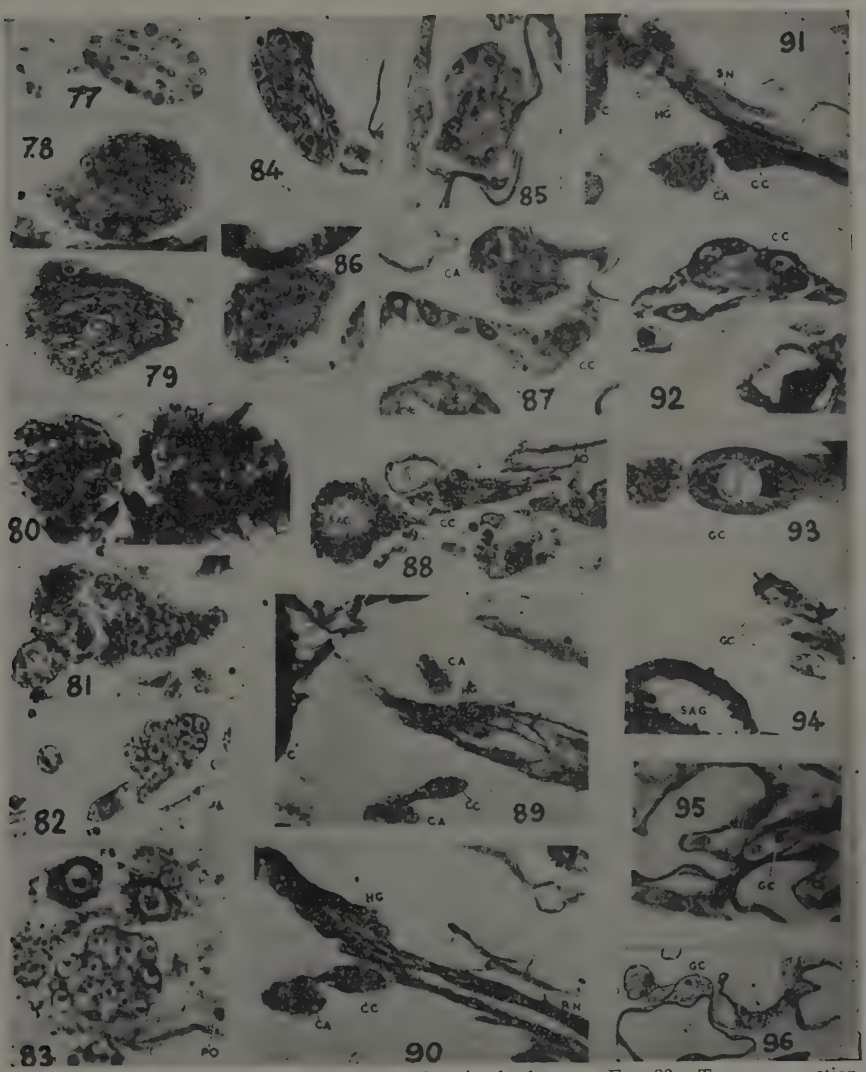
The pars inter-cerebralis is defined as that part of the proto-cerebrum lying dorso-medially, which is bounded by the corpus centrale (the central complex) and the corpora pedunculata.

The large cells of the cerebral ganglion are found in three discrete groups : a group of three giant cells, behind and on each side of the proto-cerebral bridge (Fig. 38); a lateral group of three cells in the dorsal frontal part of the proto-cerebrum, close to the giant cortical cells of the antennae, the largest cells in the brain, and on either sides of the central complex (Fig. 0); these cells are similar in position to the lateral neuro-secretory cells in other insects. The third group is a group of eight or more cells (Figs. 34, 35, 36, 39, and 42), five frontal to the median ocellar nerve and three behind the central complex.

The neuro-secretory cells are, after the antennal cortical cells, the largest cells in the brain, with large cytoplasmic content which stains very deeply in the pupa and the adult where granulated bodies are scattered in the vacoulated cytoplasm (Figs. 70, 71, 73, and 74). The nucleus is surrounded by a thin but clear ring of chromopholic cytoplasm (Fig. 72), and is rather large with a giant nucleolis and rich dotted chromatin network.

In the pupa, there is another type of cell of moderate size, with large nuclei, distinct nucleoli and rich chromatin, and deeply staining globules surrounding the nuclei. The nucleus and the surrounding globules occupy most of the cells. These cells are distributed in the cortex of the sub-oesophageal ganglion at the point of origin of the nerves of the mouth-parts, and in the dorsal cortex of the ganglion. In the cerebral ganglion, cells of this type are located in the median bundle round the central complex, especially ventrally, and at the back of the proto-cerebral lobe. That is to say that they are scattered between the tracts leading to nerves of corpora cardiaca in the brain (Figs. 39 and 40).

Inter-cellular secretions varying in size from minute granules to large droplets, can be distinguished lying between the fibres of the tracts of the corpora cardiaca (Figs. 102 and 103).



FIGS. 77-79 : Sections of the corpora allata in the larva. — FIG. 80 : Transverse section of the pre-pura. — FIG. 81 : Section of the late pre-pupa. — FIG. 82 : Section of the early pupa. — FIG. 83 : Transverse section of the pupa. — FIGS. 84-87 : Sections of the adult. — FIG. 88 : Sagittal section of the pupa. — FIGS. 89-91 : Serial longitudinal sections of the adult. — FIG. 92 : Sagittal section to illustrate the cells of the corpus cardiacus. — FIG. 93 : Garland cell of the larva. — FIG. 94 : Garland cells of the pupa. — FIGS. 95 and 96 : Garland cells of the adult.

The axons of the large cells in the pars inter-cerebralis, pass antero-medially and downwards between the transverse body of the proto-cerebral bridge and the central complex where fibres from the five frontal cells cross the three back cells. Most of the fibres seem to proceed towards the central complex (Fig. 39) to end there in the ellipsoid body or more probably in the ventral tubercles. Other fibres appear to pass downwards as the continuation of tracts of the nervi corpora cardiaca.

On the other hand, the tracts to the nerves corpora cardiaca I bifurcate just inside the brain mass. Each nerve has two nerve tracts : one runs vertically towards the transverse body of the proto-cerebral bridge, the other runs horizontally and unites with the median bundle while passing the oesophageal canal from the thoracic centres to the pars inter-cerebralis. The dorso-median cluster of certex, the neuro-secretory cells, which forms part of the pars inter-cerebralis, sends processes into the median bundle. The fibres of the vertical tract are either the continuation of the axons of the neuro-secretory cells, or they are connected indirectly with them through the ventral tubercles.

It is clear that the axons of the cells of the pars inter-cerebralis are close to the ocellar tracts. which do not end in the central complex.

The two lateral cortical groups of the neuro-secretory cells are probably the origin of the nervi corpora cardiaca II. The fibres turn downwards, joining the median bundle and the horizontal tract of the nervi corpora cardiaca I above the oesophageal canal, and leave the brain as two short slender nerves. These do not end directly in the corpora, but join the recurrent nerve just before it enters the hypo-cerebral ganglion.

It is clear, therefore, that this pair of nerves, described here as nervi cropora cardiaca II, do not follow the normal course and their homology with those of other groups is not certain.

In the adult the well developed nervi corpora cardiaca I, lie in the neck region, on each side of the aorta, surrounded by a neurilemma sheath. During its course towards the brain, each nerve passes inside the oesophageal muscles in the neck, turns round them in a semi-circle to enter the brain at a well tracheated area in the hemisphere. The aorta ends in a sinus in the neck region between the corpora cardiaca and the brain. This sinus encloses the recurrent nerve, the nervi corpora cardiaca II and the oesophageal muscles of the neck, but not the nervi corpora cardiaca I. The wall of the sinus is continued forward through the oesophageal passage between the sub-oesophageal ganglion and the brain, and its dorsal wall is extended between the antennal nerves as a narrow strip of tissue which ends in the hypodermis in the median line of the head capsule, between the compound yes and the clypeus (Fig. 44).

In the larva and in the pre-pupa, the nervi corpora cardiaca I and II unite on entering the transverse commissure of the brain, and turn laterally to merge within the brain lobes. It was not possible to follow them beyond this point.

The corpora cardiaca are well developed. They lie on both sides of the aorta close to but not attached to its walls. The hypo-cerebral ganglion lies between them in the mid-line of the prothorax, and is connected to them by few nerves (Fig. 90). The corpora cardiaca are in the prothorax, and in the adult they are at the junction of neck and prothorax. They are enclosed by the same neurilemma which surround the nervi corpora cardiaca. Both in the adult and in the pupa, they are clear elongated bodies lying close to the salivary glands and attached to them.

The neural tissue includes the cell bodies and nerve fibres from the nervi corpora cardiaca I, and from the hypo-cerebral ganglion. Each corpus is supplied by at least two nerves from the hypo-cerebral ganglion, the posterior one of which bifurcates before entering the corpus. One or more of these nerves may be considered as the extension of the nervi corpora cardiaca II, whose fibres pass through the hypo-cerebral ganglion. The corpora allata are innervated by nerves from the corpora cardiaca, but it has not been possible to determine whether these nerves are the extensions of the nervi corpora cardiaca I or II.

In the larva and in the pre-pupa, the neural structures are similar to those in the adult and the corpora cardiaca are usually detected by these nerve connections, since they are much smaller. Here again nerve connections unite the corpora cardiaca with the brain by the nervi corpora cardiaca I and II; the corpora cardiaca are united between themselves by the hypo-cerebral ganglion, and they are also united to the corpora allata by the nervi corpora allata cardiaca.

In the pre-pupa, the neuro-glandular cells are compact and very much smaller in size than the comparable cells of the corpora allata in material of similar age. The nuclei are large occupying most of the cell and the nucleoli distinct, but the nucleus inclusions are small and scattered near its surface. No vacoules or microscopical globules are present in the cytoplasm.

In the pupa and the adult these cells are very much larger (Figs. 88, 89, 90 and 91), with dense cytoplasm. The nuclei are large in comparison with those of the corpora allata, the nucleoli are distinct, and the nuclear inclusions are numerous. Numerous vacoules can be seen in the cytoplasm, and the nucleus appears to be surrounded by small dotted bodies (Fig. 92).

The hypo-cerebral ganglion (Figs. 89, 90, and 91) is enclosed by a neurilemma sheath, and consists of nerve fibres, ganglionic tissue with no apparent structure, and cells which from their structure may be expected to have a secretory function. The structure of these cells is not unlike those of the corpora cardiaca.

In the larva and in the pre-pupa, the cytoplasm is deeply staining, some vacoules are observed, and a large nucleus rich in chromatin and with a clear nucleolus of the cell. In the pupa, the cells are still deeply staining but the extent of the vacoules is greater; the nucleus is again rich in chromatin. In comparison with similar cells in the corpora cardiaca of the pupa, the cells of the hypo-cerebral ganglion are smaller and more regular in outline. In the adult, these possibly secretory cells apart from being smaller in size, have the bodies surrounding the nuclei more pro-

minent both in size and stainability. There is then a pronounced similarity between these cells and those of the corpora cardiace.

A considerable part of the ganglion is made up of nerve fibres running parallel to its long axis. Some of these pass into the connectives with the corpora cardiaca while others pass to short nerves which end in the cardia of the intestine.

The nerves corpora cardiaca II emerge from the median sides of the hemisphere of the brain, just below the nerves corpora cardiaca I. They pass inside the oesophageal neck muscles, and turn to unite with the recurrent nerve, thus putting the pars inter-cerebralis in direct nervous connection with the hypo-cerebral ganglion. These nerve connections are present in all stages.

In the larval and in the pre-pupal stages (Fig. 108), the two oesophaged nerves come out of the ganglion, continus towards backwards along the sides of the oesophagus to end on the proventriculus, forming the two ventricular. Two others nerves emerge from the corpora cardiaca, which are perhaps the extensions of the nerves corpora cardiaca II and are connected with the oesophageal nerves along the oesophagus. They pass beyond the ventricular ganglia, and end shortly after, on the ventriculus. These nerves, the stomacal nerves, have been observed both in the pupa and in the adult (Fig. 109). The true oesophageal nerves degenerate during the pupa.

The hypo-cerebral ganglion, which is well tracheated, lies between the aorta and the oesophagus, with the ventricular ganglia close to it posteriorly, and the corpora-allata-cardiaca laterally. The ganglion is large and flattened, being spread broadly along the oesophagus forming an arch within its neurilemma. The oesophageal nerve is very well developed and elongated, and the stomacal nerve extends beyond the ventricular ganglia.

In the adult, the frontal ganglion (Figs. 66, 67, 68, and 69) is situated between the cibarial muscles, controlling the cibarial pump, and the pharyngeal muscles regulating the movement of the pharyngeal pump. The clypeal muscles and the frontal muscles are separated by the frontal ganglion. All the cibarial muscles in the head of the larva are inserted on the cuticle of the clypeus anterior to the frontal ganglion connectives, while all the pharyngeal muscles are posterior to the ganglion. The cibarial musculature is clypeal in origin. The same would appear to hold for the adult, for the clypeus is in front of the frontal ganglion, connected posteriorly to the rest of the head capsule by the membranous portion of the fronto-clypeus, and all the cibarium muscles are inserted on the cuticle of the clypeus. In the larva, both cibarial and pharyngeal muscles have their origin on the clypeus.

The ganglion is an oval body tapering posteriorly and enclosed in a fine neurilemma. It lies in the mid-line of the head in front of the brain, and on the muscles surrounding the cibarial pump, which are innervated by nerves from the ventral region of the ganglion. The two frontal connectives running between the labro-frontal nerve and the ganglion, enter the ganglion laterally about one third of the distance from its posterior margin. Two frontal nerves emerge from the anterior surface of the ganglion and proceed towards, and innervate, the cibarial and

labral muscles. From the posterior surface the recurrent nerve emerges. In the pupa and adult it passes backwards in close contact with the dorsal surface of the oesophagus, finally entering the hypo-cerebral ganglion. In the larva, however, since the frontal ganglion hangs over the oesophagus instead of lying close to it, the recurrent nerve, after leaving the ganglion, runs at an angle to the oesophagus until the two meet and become parallel to each other shortly before passing through the brain. The recurrent nerve during its course, innervates the muscles surrounding the stomadeum, and the muscles of the pharyngeal pump. In the adult, the muscles of the pump are also innervated by another nerve which emerges laterally from the frontal ganglion, and turns latero-dorsally before arborizing between the muscles.

The different nerves which come out of the ganglion, form a fibrous tissue lying ventrally. This is surrounded both laterally and dorsally by ganglionic cells. Two different sorts of fibres can be observed, fine and coarse.

Ganglionic cells of two sizes are present, the large ones occupying most of the ganglion dorsally and laterally, while the small cells are located in the centre between the large cells and the nerve fibres. The small cells are few in number and, except in the pupa, each cell is small in size, with little cytoplasm, the nucleus relatively large and containing very rich and deeply stained chromatin. In the pupa, the nucleus occupies almost the whole cell, with some microscopical granular bodies surrounding it, and includes a distinct nucleolus surrounded by rich scattered chromatin. In these cells the cytoplasm, if present, is not stained with Gomori. In the large cells, which are numerous, the nucleus is rather large including rich chromatin and a nucleolus, and some vacoules in all stages. In some preparations neuralia were noticed as small elongated cells containing gliosomes.

The pericardial cells (Figs. 93, 94, 95, and 96) surrounding the endocrine glands, are obvious in the larva and in the pre-pupa, they reach their greatest size, each cell being slightly more than half the size of the corpus allatum. Each cell has two large nuclei, and the cytoplasm stains deep blue with Azan. Some granules are present and there are numerous vacoules whose contents stain blue. The garland lies round the oesophagus, surrounded by the salivary glands, behind the brain and beneath the corpora allata. The cells appear to reach their most active state in the pre pupa. In the pupa, the cells with highly vacoulated cytoplasm, containing few microscopical particles still retain the two nuclei for each cells; each nucleus has a nucleolus. In the newly emerged adult, there is a garland on each side of the neck region, above the corpus allatum, and around the ventral wall of the tracheal trunks. Each cell of the garland has an enormous central vacoule containing a slime-like secretion. Finally, these cells degenerate losing their nuclei. The cell inclusions disappear shortly afterwards, so that nothing is left except the outlines of the cells which are distinguished from the surrounding fat body sheaths by the difference of their stain reaction (Fig. 104).

The abdominal and metathoracic pericardial cells are smaller and do on show this cycle, although they possess the morphological peculiarities of the garland cells.

FIG. 97 : Sagittal section of a very early female pupa. — FIG. 98 : Transverse section of a pupa. — FIGS. 99-103 : Serial sagittal sections of a pupa. — FIG. 104 : Sagittal section of the adult female. — FIGS. 105 and 106 : Serial sagittal sections of the pre-pupa. — FIG. 108 : Longitudinal section of the pre-pupa. — FIG. 109 : Sagittal section of an adult male. — FIG. 110 : A mass of eggs laid in the laboratory with some scattered eggs near it. — FIG. 111 : Cocoons formed in the laboratory.

A structure with muscular elements has been found in the dorsal part of the prothorax in the larva and in the pre-pupa only. They consist of three pairs each of which surrounds bundles of dorsal inter-segmental horizontal muscle-fibres. Each muscle is contained within a sheath containing massive cells (Figs. 105, 106, and 107). These cells are spindle-shaped towards the two poles and round in the middle. The cytoplasm is dense without vacoules, and deeply staining except round the nucleus where there is a thin but clear ring of chromophobe cytoplasm. The cytoplasm, which occupies much of the cell, is rich in chromatin, and includes a distinct nucleolus. In the four inner structures although the sheathing tissue is thick nevertheless the muscles themselves form most of the structure, while in the two lateral ones, the muscles are very much smaller, probably just sufficient for attachment to the muscle tendons. These muscles are located in the mesothorax between the dorsal longitudinal muscles and the mesothoracic tergite, on both sides of the aorta. At both ends of the mesothoracic segments, they are attached to the cuticle by tendons, lying close to and above the spiracles. In the late pre-pupa, when the remaining larval thoracic muscles break down and the imaginal muscles are differentiating, the muscles of the glands are retained. They break down in the early pupa (Fig. 97) where the sheaths separate from the degenerating muscles and themselves disappear soon afterwards. One structure is left on each side which may be the remains of the two lateral ones described above. They are attached only by their anterior ends near and above the prothoracic spiracles, and between the dorsal imaginal thoracic and leg muscles. At this stage, the glands are represented by a median, lightly striated, degenerating muscular core, on each side of the thorax (Figs. 98, 99, 100, and 101). The structures are surrounded by highly vacoulated cells some of which contain a few large droplets, but the majority are empty. Each nucleus is usually large and surrounded by dotted thread like rods. In the adult, there is no trace of these structures.

XI. THE ORGAN OF PALMÈN

The organ of Palmèn (Figs. 51-65) is present. Since it lies close to the corpora-allata-cardiaca, and the aorta, its development has been studied to show its relations with these structures.

In the prothorax of the larva, the two main longitudinal dorsal tracheal trunks are connected by two transverse dorsal tracheal commissures. The tracheae entering the brain are supplied from the frontal transverse commissure, and in the centre of this commissure lies the organ of Palmèn. The commissure passes across at right angles to the aorta, and the organ lies in this part of the commissure that crosses the aorta. The dorsal wall of the aorta makes a slight concave surface at that spot, on which the organ of Palmèn rests. The walls of the organ and the aorta do not fuse, and although they are touching in the larval stages, they are separate in the pupa. The organ lies beneath the two dorsal fat body lobes, and just above

the corpora allata so that it may be usually taken as a landmark for them. Long chitinous fibrils from the commissure and from the organ, are attached to the aorta and the fat body lobes. The organ is chitinous and consists of inter-fitting nodes, the internal surface of each node being marked by small processes scattered over the internal surface and extending towards the external surface of the successive node. In sagittal sections, these nodes appear as more or less circular rings, while in other planes, they are more irregular. That rings are obtained in preparations out in any plane, indicated that the body is composed of a series of hollow spheres contained one within another.

In the full grown larva, pre-pupa, and in the pupa, at least seven rings can be counted. To find out how many laminae these rings represent, it must be remembered that these structures having thickness, should have two (external and internal) walls; each two rings represent one sectioned lamina.

In the centre of the transverse commissure a node is formed and during moulting the commissure breaks on both sides of the node, before it is shed leaving the node attached to the one of the previous instar.

It is probable that the organ consists of the chitinous wall of the tracheal node which is not shed at moulting, though it is not clear why it should appear as a series of concentric spheres. The processes may be considered as the taenidia of the node intima which consists of separate ridges rather than of spiral thaenidia as in the rest of commissure. If this is so, then the number of laminae present should correspond to the number of ecdyses, and the number of apparent rings to twice this number. Six rings might therefore be expected in the pre-pupa after the wall of third larval instar had been shed and in the pupa, surrounded by two rings of the functional node.

In the young adult the organ is still present, apparently free within the air sac which has replaced the commissure, but in older adults it could not be recognized.

XII. PHAGOCYTES AND THE FORE-GUT

Shortly before pupating, phagocytes appear surrounding the fore-gut, the oesophagus, and the compound eyes. In the pupa, phagocytes are seen accumulating round the back of the brain, the sympathetic nervous system, the cibarial muscles, and the optic glomeruli, forming a more or less phagocytic tissue.

The larval muscular coat of the fore-gut degenerates and is phagocytozed in the pupa. These degenerating cells were mis-interpreted earlier in this work as the homologue of the peritracheal gland of Possompés.

In the larva and in the pre-pupa, the imaginal gut is enclosed by a thin membrane, and is surrounded by the larval muscular coat (Figs. 105 and 106). As the larval muscles degenerate, the imaginal gut, which is folded during the larval stage, expands, and the epithelium is exposed. No mitoses were noticed in the cells

of the imaginal epithelium, and it seems that in these cells increase in size takes place as the gut expands, but no proliferation.

XIII. THE FAT-BODY

The result of the search for the prothoracic glands within the fat body was negative. However, the following is an account of observations on the fat body during different stages.

The diapause occurs in the full grown larval stage, during which there is hardly a slight movement if any, and ends within the pre-pupal stage. In the diapause larva, the fore and mid-gut contain solid food, and it is not known yet whether or not digestion takes place on a narrow scale, but food seems to decrease during the pre-pupa, and the gut is clear just before pupation, and the pupal mid-gut contains only slime. The breakdown of the fat body cells starts in the pre-pupa in the thorax round the gut and the corpora-allata-cardiaca complex. The fat body is arranged in lobes (Figs. 105 and 106) endued in delicate connective tissue membranes. In the larva, each cell is small containing vacoules which themselves contain food globules; most of the nucleus is occupied by deeply stained inclusions. In the pre-pupa, the cell increases in size, the globules break down into numerous granules and are kept within the cell walls (Fig. 97). In the pupa (Figs. 83 and 100) each cell is at its maximum size, full of numerous particles, while the nucleus is very big with rich inclusions and surrounded by a thick cytoplasmic ring of high stainability and including small rounded bodies. In the adult, few scattered fat granules are left, while nucleus inclusions decrease so that a nucleolus is distinguishable. In six days old adults, the cells do not contain any inclusions. The cells are along the aorta, and also occupy most of the cavity of the head and thorax, which is not occupied by anything else.

The inclusions of the fat body cells, specially during the pupa, are different in size, shape, and reaction to stains. The nucleus and the ring surrounding it are so complicated, that thorough investigation is needed to express their importance.

XIV. SUMMARY AND CONCLUSIONS

A study has been made by means of the normal development of the nervous ystem of *Bibio marci* (L.) in all stages.

The following pairs of nerves arise from or pass to the brain and sub-oesophageal ganglion in all stages, though their course and branches differ greatly in larva and adult : antennal with tegumentary branches, labro-frontal, mandibular, maxillary, labial, and occipital. The labral, mandibular and maxillary nerves are connected with each other by short neural connectives. In the adult, the antennal,

mandibular and maxillary nerves, all have branches to the fenestrated zone of the compound eyes.

The normal elements of the stomato-gastric (sympathetic) system are present in a relatively unconcentrated form. Both nerves connecting the corpora cardiaca to the brain are present. Garland cells and prothoracic glands are present. The sympathetic nervous system is of a generalised type. The ring-gland consists of the corpus allatum, the corpus cardiacum, the homologue of the peritracheal glands in Nematocera, and probably the hypo-cerebral ganglion.

The gross morphology of the corpora and major tracts of the brain are described. The apparent structure of the incretory and other cells of the stomato-gastric system has been described in relation to activity in various stages.

The compound eyes in the male are much more developed than those of the female. The frontal division of the male does not show any sign of degeneration. The two pigmented bodies may be interpreted as specific larval stemmata which exist in the adult and serve as photo-receptors.

The organ of Palmèn is present in the transverse tracheal trunk in the larva and remains as a rudiment in the adult air sac. Such organs have not been previously described in the Endopterygota.

It is highly probable that Bibionidae are one of the most primitive insects among the Nematocera.

XV. ACKNOWLEDGMENTS

The work was carried out with the aid of a grant from the Ministry of Agriculture of Egypt.

I should like to express my gratitude to Professor D.M.S. Watson (F.R.S.) and to Professor P. B. Medawar (F.R.S.), for the facilities that they have provided in the Department of Zoology and Comparative Anatomy in the University College of London. My thanks are also due to Professor B. Hanstrom, and his assistants, at the Zoological Institute of Lund.

Finally, I have pleasure in acknowledging my deep gratitude to my supervisor Mr. R. B. Freeman for his patience in advice and criticism.

XVI. ABBREVIATIONS OF FIGURES

AC, accessory proto-cerebral central commissure; ACS, antennal commissure underneath the oesophagus; AD, antennal depressor; AG, antennal glomerulus; AI, anterior inner glomerulus commissure; AIG, anterior inner glomerulus commissure; AN, antennal nerve; AO, aorta; AS, air sac; AT, anterior optic tract. — B, brain. — C, cardia; CA, corpora allata; CB, central body; CC, corpora cardiaca; CL, corpora pedunculata; CM, commissure between optic tubercles in

front of the median bundle; CX, cortex; CCO, corpora cardiaca nerve I; CCII, corpora cardiaca nerve II; CCS, central commissure; CCX, central complex; CIC, circum-oesophageal connective; CUD, cuticle (cranium) of adult; CUL, cuticle (cranium) of larva; CUP, cuticle (cranium) of pupa. — DC, dorsal posterior commissure. — EB, ellipsoid body; EC, external chiasma; EFO, extension of frontal ocellus; EG, external glomerulus. — F, front-dorsal transverse tracheal commissure; FC, frontal connective; FO, frontal ocellus; FZ, fenestrated zone. — GC, garland cells. — H, hypodermis; HG, hypo-cerebral ganglion. — LM, layer of monopolar neurones. — MB, median bundle; MC, middle glomerulus connective; MG, middle glomerulus. — OE, oesophagus; OEN, oesophageal nerve; ocellar fibres; OG, olfactoria globularis; OM, ommatidia; OMF, ommatidia folds; OMI, ommatidia for frontal part of eye; OPL, optic lobe; OS, ocellar stalks; OT, optic tubercle. — PB, proto-cerebral bridge; PBD, pigmented body; PBN, pigmented body nerve; PC, proto-cerebral central commissure; PF, posterior tract of giant fibres; PG peripheral ganglion; PG1, posterior inner glomerulus; PGL, prothoracic glands; pars inter-cerebralis; PIC, pars inter-cerebralis cells; PIT, pars inter-cerebralis tract; PL, proto-cerebral lobe; PO, Palmen organ; POG, peripheral occipital ganglion; PTC, proto-cerebral transverse commissure. — RN, recurrent nerve. — SA, secondary antermal centre; SB, supra-oesophageal ganglion; SG, sub-oesophageal ganglions; SN, stomachal nerve. — T, tentorium; TN, tegumentary nerve; TR, tracheae. — VG, ventral ganglion; VT, ventral tubercle.

COMPARISON BETWEEN A WET AND A DRY METHOD FOR EXTRACTION OF SOIL ARTHROPOD FAUNA

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TULLGREN improved BERLESE funnel by inserting electric light for the purpose of repelling soil fauna by light, by dessication, and by raising the temperature of the soil. Flotation methods were more or less improved by several investigators. The advantages and disadvantages of extracting the soil arthropod fauna by the TULLGREN or by the flotation methods has been studied by various authors. For purpose of comparing the two methods fifteen pairs of random samples were obtained from a fallow area of clay loam soil type from a farm at Giza, during April, 1957. One of each pair was treated by the TULLGREN funnel method and the other by the SALT and HOLLICK's flotation method. Each sample measured 4 inches in diameter, and was taken off to a depth of 15 inches below the soil surface. A comparison between the two methods and the results obtained under Egyptian conditions, are summarised hereafter.

1. — The Insecta obtained by the TULLGREN method amounted to 380 (50.6%), of which 210 (74.7%) Collembola, 18.(75%) Hemiptera, 64 (39.3%) Thysanura (*Heterojapyx*), 8 (9.4%) Thysanoptera, 9 (60%) Psocidae, 4 (19%) Homoptera (Aphididae), 8 (32%) Coleoptera, 6 (37.5%) Coleoptera larvae, 53 (91.4%) Diptera. The Myriapoda (*Scutigerella*) amounted to 19 (38.8%), the Spiders to 7 (28%), and the Mites to 192 (71.9%).

With the flotation method 378 (49.4%) Insecta were counted, of which 71 (25.3%) Collembola, 6 (25%) Hemiptera, 99 (60.7%) Thysanura (*Heterojapyx*), 77 (90.6%) Thysanoptera, 6 (40%) Psocidae, 17 (81%) Homoptera (Aphididae), 17 (68%) Coleoptera, 10 (62,5%) Coleoptera larvae, 5 (8.6%) Diptera, 21 (100%) Diptera pupae, 2 (100%) Hymenoptera, 27 (100%) Hymenoptera pupae. The Myriapoda (*Scutigerella*) obtained amounted to 30 (61.2%), the Spiders to 18 (72%), and the Mites to 75 (28.1%). It is assumed, in estimating the previously mentioned percentages, that the total number obtained by the two methods for any group, as Collembola, Hemiptera, etc., is 100 individuals.

2. — The TULLGREN funnel method was found more satisfactory for extracting Collembola, Hemiptera, mites, and Psocids. A great amount of Diptera, mainly Culicidae and Chironomidae, was attracted by light on the funnel.

3. — Thysanoptera, Aphids, Coleoptera, Hymenoptera, Spiders, Thysanura, Myriapoda, and all pupae, were better extracted with the flotation method.

The total number of Arthropoda secured by both the methods, amounted to 1099, of which 598 (54.4%) were obtained by the TULLGREN method and 501 (45.6%) by the flotation method.

ON THE BIONOMICS ON *DACUS CILIATUS* LOEW

[*Diptera* : *Trypanaeidae*]

(with 6 Text-Figures)

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In a previous paper published in this Bulletin (pages 493-495), the present author has already stated that *Dacus ciliatus* Loew breeds but only on cucurbits. The appearance of this fruit-fly and its subsequent rapid increase into a serious pest under extreme favourable conditions, presented a real menace to all cultivated cucurbits in Egypt. These host-plants are recorded here according to their degree of infestation: *Cucumis pubescens*, *C. melo dudaim elongatus*, *C. sativus fructominosus*, *C. sativus flexuosus*, *Cucurbita pepo*, *Cucumis citrullus*, *C. antulatus*, and *C. lagenarius*.

Dacus ciliatus is of Ethiopian origin. It is recorded as existing in the Sudan from where undoubtedly it must have migrated to Egypt. To support the foresaid theory, it can be said that the raising up of the Aswan Dam has created major changes in our cultivation system. Most of the land in front of the Dam is now cultivated more than once a year. The land behind the Dam, which is used as a water reservoir during the rest of the year, can be cultivated during the flood period. On account of the short durability of cucurbits, they are grown along the Nile bank just after the flood season. The availability of cucurbits all over the year, in vast acreage, made it possible for the fruit-fly to establish itself. In the other hand, the availibility of Colocynth or Bitter apple (*Citrullus colocynthus*) in enormous amounts during winter (the off season of cucurbits), is the main factor for the establishment of the pest. This plant is widespread in the desert area east and west of the Nile valley in Upper Egypt, and in the northern part of the Sudan.

Dacus ciliatus has spread rapidly and vigourously towards the north due to the cucurbits cultivation all over the year. It is assumed that it has already been established every where in Upper Egypt, including the Fayoum, in the southern parts of the Delta, and in the Canal Zone up till Ismailia. Infestation continues all over

the year in Upper Egypt, the highest one occuring between February and May. In Lower Egypt, infestation takes place in summer and reaches its peak by late summer and the beginning of the autumn (September-October).

The individuals of *Dacus ciliatus* occuring in Egypt, are rather similar to those in the Sudan. However, there are obvious morphological differences between individuals from one area at one time, especially in the distribution and variation of the dark spots on the dorsal side of the thorax and abdomen (Fig. 1).

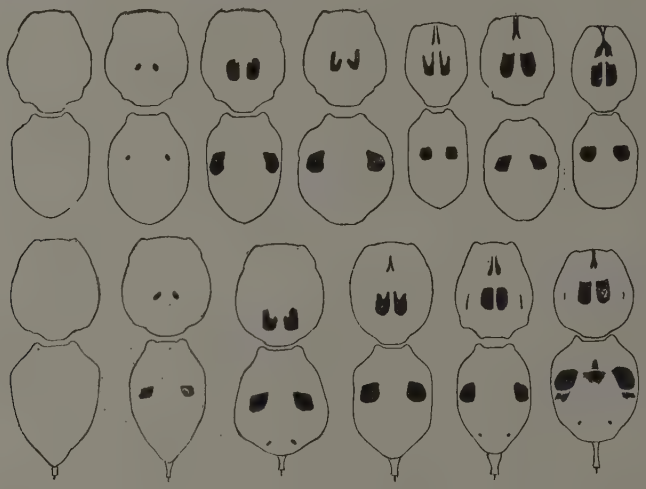

Fig. 1 : Morphological differences, and distribution and variation of the dark spots; dorsally.

Biology

Dacus ciliatus hibernates as adult, hiding under shelter or between cracks, but it does not enter diapause. Copulation and egg-laying occurs when fruits are available. Very young fruits of cucumber, marrow or melons are infested as much as full grown ones.

Eggs are white, elongate, crescent-like, and measure 1.3 mm. long and 0.2 mm. wide. They are deposited in bunches in wounds made by the female into the plant tissue. Under favourable nutritional and climatic conditions each female may lay from 5 to 50 eggs. As fruits can be infested more than once, it is common to find more than one egg-bunch in each fruit (Figs. 2 and 3). Hatching usually occurs within four days under laboratory conditions, probably three outdoors, but more than four days in cold weather.

Larvae are yellowish in colour, and burrow into the plant tissue on which they feed. Within 15 to 18 days the full-grown larva, through the help of its character-

istic jumping, leaves the fruit to pupate in the soil. Most of the exit holes face the soil and are usually used by more than one larva deserting the fruit.

It can be noticed that various kinds of micro-organisms deteriorate the fruits, in association with the fruit-fly attack. Such micro-organisms usually accompany the eggs during oviposition, and are also associated with the newly hatching larvae

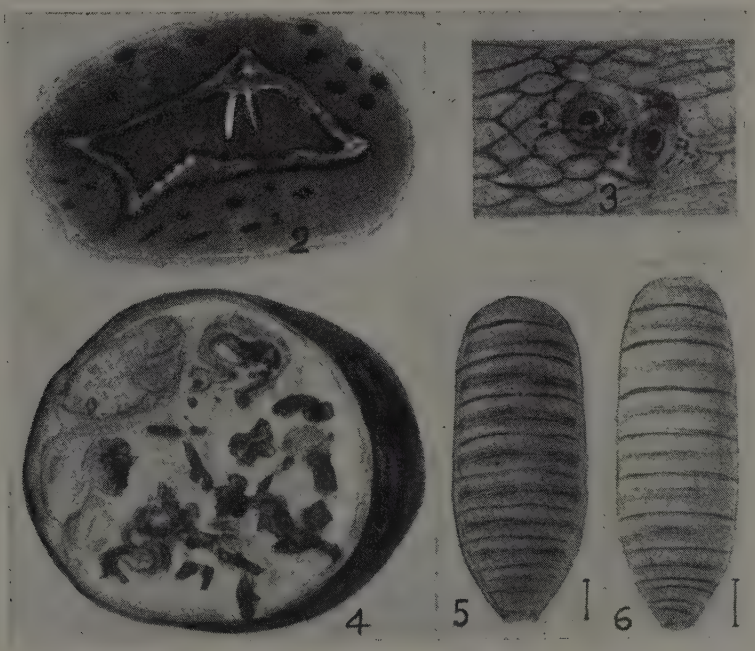

FIG. 2 : Eggs laid on cucumber. — FIG. 3 : Infestation on cucumber. — FIG. 4 : Internal damage made by larvae. — FIG. 5 : Larva of *Dacus ciliatus* Loew. — FIG. 6 : Larva of *Leptoxyda longistylus* (Wied.).

during their movements and their tunnelling (Fig. 4) in the fruits. For as much the fly cleans its ovipositor with its hind legs, this later is loaded with similar foresaid yeast or bacteria. These micro-organisms render the plant tissue more digestible and constitute a favourable factor to the development of the newly hatching larvae at least.

Pupation within the fruit is rarely observed. Under laboratory and under normal conditions, the pupal stage lasts for three weeks, and longer when temperature drops. A significant increase in the duration of the pupal stage is observed when the soil sheltering the pupae is not well aerated due to its structure or to the increase of its water contents. In the laboratory, adults were able to emerge when pupae were

kept in desiccators containing dry air. At the same time, when fifty pupae and adults were kept in a cool chamber 4-8°C, they stood alive for a complete month, and pupae were able to reach the adult stage.

Adults feed almost immediately after emergence. In the laboratory, they were fed with sugar solution, honey dew, or cell sap of cucurbit fruits being scratched or pierced by the ovipositor. Ripe dates and honey can also be used, but the former is essential for egg production. Outdoors, nectar, honey droplets, or honey dew secreted by other insects are fed upon by the fly. Cucurbit fruits exsudation due to ovipositor punctures can also serve as food.

Since both sexes are in constant movement on the plants during the whole day, their bodies will be in direct contact with insecticides if spread as a thin film. Furthermore, the proboscis of the flies being frequently in contact with the plant surfaces, and considering their habit in regurgitating and imbibing, insecticides might easily poison them.

Copulation occurs in the breeding cages as easy as in the fields. Copulation and oviposition were noticed in the fields during the whole day except in too hot weather when flies hide between plant leaves to escape direct sunrays. At noon and up to the very early morning the flies cease all activity.

The gravid female is unable to produce eggs before six days from emergence. Its ovipositor is rather long, telescopic, and appears in full when prepared for oviposition. More than one puncture is made to the fruit to test its fitness in keeping the brood, and each time the female imbibes the produced cell sap. No eggs are deposited unless the fruit is fresh and capable of keeping them. In the laboratory, egg-laying on divided or stale fruits is unliked and occurs because the female usually has to get rid of her eggs. At egg-laying, the ovipositor assumes its full length and curves downwards, while the wings are stretched horizontally, both at right angle to the longitudinal axis of the body. The ovipositor is entirely introduced into a suitable fruit, sticks to the puncture thus formed, streches for depositing the egg, retracts to leave the egg in its place, and so on until a bunch of eggs parallel to the fruit surface is formed. This operation lasts for about fifteen minutes, after which the ovipositor is withdrawn from the wound. Juicy secretions of the fruit fills the wound, although such is partially imbibed by the fly. A short rest is taken by the fly before producing another bunch of eggs, and so on. As to the sap which is secreted by the wounds, it gradually dries and assumes the aspect of a resinous substance which indicates the most important symptom of infestation. Sometimes a rather big cavity, covered by the resinous substance, is formed by the collapsing cells damaged by the ovipositor and the continuous growth and expansion of the living cells surrounding the collapsed ones.

Hundreds of fruits of cucumber have been examined, and it was found that the holes containing the egg-masses are not confined to any particular area. For each hundred holes facing the soil, there were 30 lateral, 37 top, and 25 near the dattackeen d of the fruit.

The quantity as well as the quality of the host fruit tissue affects the size and vigour of flies produced thereon. For instance, larvae and adults feeding on bitter apple are smaller while their broods are in normal size when bred on cucumber.

CONTROL

Two points are to be raised before discussing the principle of control.

1. — The excess of irrigation water and manure do not stop infestation in cucumber fields, but only accelerate the fruit growth in such a way that infested cucumber fruits reaches the consumer before eggs hatch, or slightly afterwards. The delay in their consumption give way for the appearance of infestation.

2. — Searching for attractants for traps, the following material (1/2-2% concentration) was tried, with negative results for both sexes : clove oil, methyl eugenol, eucalyptus, menthol, and di-ammonium phosphate.

1. Methods of control

1. — Introduction of beneficial parasites from abroad in view to reduce or to control *Dacus ciliatus* damages.

2. — Cucurbits fields should be kept always clean, and all infested fruits eliminated without delay to save a major portion of the crop.

3. — After fruit gathering, the vegetative part of the plants must be removed immediately since such plants carry off-season fruits highly infested with the fruit fly. Another step to be taken is the elimination of bitter apple plants (*Citrullus colocynthis*).

2. Chemical control

1. — It was noticed that *Dacus ciliatus* often hides amongst weeds surrounding and at the borders of cultivated fields; consequently, when chemical insecticides are used on crop as a measure of control, it is advisable to treat also the borders of the field.

2. — Cucumber is usually sent to market within a week or little more of the fruit formation, while besided crop collection is continuous at small intervals, This fact leads to the residual hazards problem. Since *Cucumis melo* and *Cucurbita pepo* remain for a longer time than cucumber in the fields before marketing, the residual problem is less serious. Since *Dacus ciliatus* passes the whole day in fields and on wild plants surrounding them, it is expected that chemical control would be more effective, providing that the border is treated also.

Preliminary field experiments were conducted during 1955 in Kom-Ombo and Giza. The following compounds seemed promising : DDT, DDT + Lindane, Lindane, Methoxychlor, Diazinon and Dipterex. The last two compounds are interesting, since preliminary observation showed no increase and usual depression,

with no building up again of the red mite. However, workers should be under technical supervision when using these two compounds. Methoxychlor causes scorches to cucumber leaves at 3% concentration or more as pure ingredient. Pyrethrum in kerosine + piperonyl butexide should not be overlooked in further research as insecticides with less residual hazards. When randomized complete blocks were set up in field experiment, it was noticed more than once that each treatment does not give any significant difference, because the effect of an insecticide is not confined to its treated block, but also to those surrounding it. It is impossible to stop such interaction of insecticides since most of the recent ones are volatile, and that air is responsible for such effect. To overcome such difficulty, an experiment was carried out at Kom-Ombo. A border of corn was planted surrounding each block. DDT at 3% pure ingredient and DDT 3% pure ingredient + Lindane 3% pure ingredient were sprayed on cucumber. The percentage of infestation was recorded as follows :

A. DDT experiments

Treatment	1	2	3	4	Total	Average
Control	14.4	16.2	4.4	15.3	50.3	12.50
Border only	8.8	6.8	8.7	7.9	32.2	8.05
Border + block	5.3	6.0	5.4	5.0	21.7	5.42
Border + block (1)	5.4	2.0	9.0	5.4	21.8	5.45

(1) Fresh smelly manure war added to these blocks to and out whether the organic matter is attractant to gravid females or not.

L.S.D. was calculated statistically as 1.4860. It was found then that there is a sianificant difference between the control and any other treatment, that the treated field + border is less infested than when the border is treated alone. However, the organic substance did not attract females more than usual.

B. DDT and DDT + Lindane experiments

Treatment	DDT		DDT + Lindane		Total
	1	2	1	2	
Control	14.4	4.4	39.3	20.0	78.1
Border only	8.8	8.7	26.0	7.3	50.8
Broder + block	5.3	5.4	5.4	4.5	20.6
Border + block (1)	5.4	9.0	3.5	9.7	27.6
Total	33.9	27.5	74.2	41.5	177.1
Average	15.35		28.9		

(1) Same remark as recorded in Table A.

When analysed statistically, no significant difference was found between the two treatment; this is not strange since it is well known that Lindane is seriously effected with such heat in Kom-Ombo. Such problem was also faced by entomologists working in the tropics, and must be kept in mind when recommending insecticides in hot areas.

Replicates are not mentioned by random, as their distribution is similar to the design of the Tables given above. Each block contained six rows, the infestation percentage being recorded from the two inner ones only.

To my colleague A. SHOEB I express my sincerest thanks for the help given in the statistical analyses.

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MOSQUITOES COLLECTED IN SOUTHERN SINAI

[*Diptera*]

(with 3 Text-Figures)

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Out of the 26 species of mosquitoes occuring in Egypt, four of them are only found in the Sinai. These are *Anopheles turkhudi* Liston, *Anopheles rupicolus* Lewis, *Culex sinaiticus* Kirk., and *Culex arbieeni* Salem. Two other species, *Anopheles superpictus* Grassi and *Anopheles dthali* Patton, are rare in the Nile Valley and in the Libyan Oases, but are of frequent occurrence in the Sinai.

The following notes concern the material (eggs, larvae and adults) collected in November 1955 during a trip to El-Tor and the Monastry of St. Cathrine.

Anopheles (Myzomyia) rupicolus Lewis

A species described from the Sudan in 1937. *Anopheles aegypti* Salem, described in 1938 from Wadi Taba in Sinai, is similar to *ripicolus* Lewis.

Several fourth-stage larvae were collected from a small collection of water at Wadi Feiran Oases. The breeding place was circular, about a meter in diameter, deprived of vegetation, and was swarming with *Theobaldia longiareolata* Macquart larvae which were visible to the naked eye in the very clear water. *Culex deserticola* Kirk. and *Anopheles dthali* Patton were also found in the same place, though in a lesser quantity.

The larvae of *Anopheles rupicolus* Lewis and of *Anopheles sergenti* Theo. are very much alike and, to our opinion, the three taxonomic characters given by SALEM in his key to the larvae of Egyptian species (included in SMART's key to the larvae of the Palaearctic Region, 1948) were found to be unsatisfactory. Firstly, the number of teeth (7 and 9) occuring on the mentum in the two species does not seem to be a reliable character. As to the second character, no constant difference in the length of the anal gills in the two species was observed. This is quite in agreement with KETTLE's (1948) view regarding the size of the anal gills in *Anopheles sergenti*. He concludes that although under certain conditions the length of the

gills may prove to be a usefulspecific character, yet it is unlikely to be a critical one. The third character given by SALEM, viz. the presence of the posterior tergal plate on the second to the seventh segments in *Anopheles rupicolus* and on the third to the seventh segments in *Anopheles sergenti*, is more reliable though in a few larvae the posterior tergal plates were found to occur on segment II in the latter species. The markings on the head in the two species, however, can afford an important character for the separation of the two species. In the fourth-stage larvae of *Anopheles sergenti* collected in the Oases of the Libyan Desert and in the Sinai, there exists invariably a distinct transverse dark band just posterior to the frontal

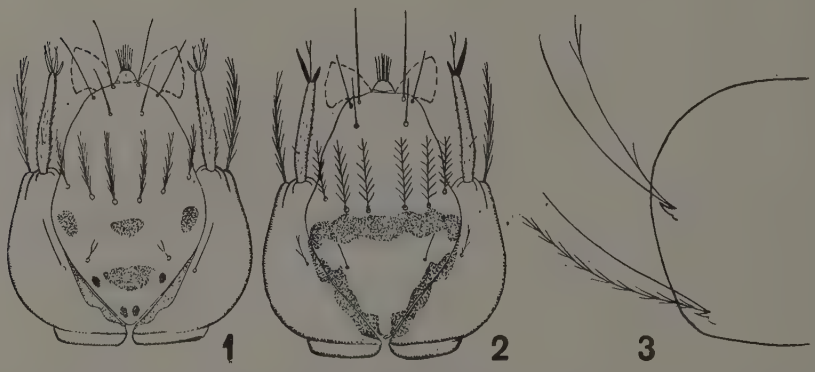

FIG. 1 : Head of *Anopheles rupicolus* larva (after SALEM, 1938). — FIG. 2: Head of *Anopheles sergenti* larva (original). — FIG. 3 : Splitting in the anterior mesopleural hair of *Anopheles dthali* larva.

hairs, while in *Anopheles rupicolus* this band is either absent or reduced to three spots and, moreover, these spots, when present, lie posterior to the frontal hairs (Figs. 1 and 2). The clypeal hairs, in both larvae, are usually simple, but the occurance of one lateral branch or the splitting of one hair at its end are not uncommon.

Anopheles (Myzomyia) dthali Patton

Recorded by KIRKPATRICK (1925) from North and North-East Sinai, under the name of *Anopheles rhodesiensis* Theo., and by SALEM (1938) from Southern Sinai (Wadi Isla and Arbieen). Larvae were found at El-Tor (Eldeesa) in January, 1951, in brackish seepage water together with larvae of *Anopheles multicolor*. In November 1955, the same place was visited again, but only *Anopheles multicolor* larvae were found. In Wadi Feiran Oases, *Anopheles dthali* larvae were found breeding in the same place described above for *Anopheles rupicolus* larvae.

Anopheles dthali larvae were found to correspond closely with the description given in EVANS (1938) and SALEM (1938), but the following two features were observed :

1. — Splitting of the anterior long mesopleural hair along its whole length was noticed in some specimens. In some larvae the splitting was found to occur 2 or 3 times, so that such hair appears to have up to four lateral branches, and thus the character of the hair was mashed (Fig. 3); but other characters, including the mesopleural hairs on the other side of the same larvae, usually ascertain the identification.

2. — The paired accessory tergal plates were found to occur very distinctly on abdominal segments 1-VII, while the posterior tergal plates occui on segments III-VII, thus each segment of segments I and II possesses an anterior tergal plate and a pair of accessory plates, but no posterior tergal plate.

Anopheles (Myzomyia) multicolor Camb.

Previously recorded from North and North East Sinai. In Southern Sinai, it was found at Eldeesa (near El-Tor) in a brackish seepage water, together with *Anopheles dthali* and *Culex deserticola* Kirk. Ribbons containing *Anopheles multicolor* eggs were also found in abundance floating on the surface of the water and visible to the naked eye. The important character or this egg is the absence of floats, characteristic of most anopheline eggs. Other *Anopheles multicolor* larvae were found in a running narrow stream at Wadi Feiran Oases together with few *Anopheles sergenti* larvae. The water in the stream was flowing from a spring and contained algae and other green vegetation. Several stones and reeds were present in the water and found to harbour numerous *Simulium* larvae and pupae.

Anopheles (Myzomyia) sergenti Theo.

First recorded in Sinai, at Ain Musa, by KIRKPATRICK (1924). Subsequently found by SALEM (1938) in North-East Sinai. At El-Tor, larvae occured in streams flowing from springs, in January 1951. The same breeding places were visited again in November 1955 and proved to be free of mosquito larvae. Few larvae were also found at Wadi Feiran Oases.

Theobaldia longiareolata Macq.

KIRKPATRICK found this species in North Sinai. At El-Tor, it was collected in wells and cisterns, and at Wudi Feiran Oases it was abundant in a small collection of surface water (see above) together with *Anopheles rupicolus*, *Anopheles dthali*, and *Culex deserticola*.

Aedes caspius (Pallas)

Previously recorded from Bir Fuwara by KIRKPATRICK. Larvae were found in brackish seepage water in Eldeesa (near El-Tor) together with *Anopheles multicolor* larvae.

Culex deserticola Kirk.

This is the first record of this species in Sinai. It was described from the Eastern Desert of Egypt (KIRKPATRICK, 1925) and subsequently found in all oases of the Libyan Desert (GAD, 1956). In Sinai, it occured at El-Tor in brackish seepage water, and at Wadi Feiran Oases in the breeding place swarming with *Theobaldia longiareolata.*

Culex pipiens L.

The only previous record of this species in Sinai is from El-Arish and Bir Fuwara, east of Ismailia (KIRKPATRICK). At El-Tor, it was found breeding in abundance in wells common in the yards of houses where numerous egg rafts were also present.

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METHODS OF MEASURING THE SPIRACULAR ACTIVITY OF INSECTS

(with 2 Text-Figures)

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I. DIRECT OBSERVATION METHOD

It is needless to say, save for the importance of the spiracular (stigmatic) regulatory mechanism in insects' control and their existence on land, methods for measuring the spiracular activity may not attract attention. Such mechanism is indispensible to insects because it regulates moisture loss, gas exchange, and keeps away dust particles, spray droplets and fumigants. Its absence was the possible limiting factor in the evolution of *Onychophora* (MANTON and RAMSAY, 1937). The evolution of insects as a group of terrestrial organisms was supposed to be largely facilitated by acquiring such mechanism (HASSAN, 1942). Entry of rotenone dusts into the spiracles of *Melophagus ovinus* L. increased the rate of its action (WEBB, 1945). ROY and GHOSH (1944) reported that *Chrysomyia megacephala* with their spiracles blocked did not respond as readily as the normal insects to pyrethrum dusts.

This paper is primarily concerned with pointing out the disadvantages of the direct observation method. The effect of CO_2 and lindane on the cockroaches spiracles is also studied by this method. Simply stated, the direct observation method entails the observation of the opening and closing of the spiracles under a binocular microscope, and manually recording these movements on a revolving drum.

Materials and methods

A total of ten male, laboratory reared American roaches, *Periplaneta americana* F., were used in this experiment. They were picked up from a roach culture which fed on hydach mixture. Five of these roaches were treated topically each

with 0.015 ml. of 0.13 % lindane-acetone solution while the other five were untreated. The treated roaches were not used in the following experiment before showing symptoms of toxicity (stage of convulsion).

In order to study the spiracular activity, each of these roaches was place on a slide with its ventral side facing upwards. The roach was tied to the slide by a thread around the neck and the forepart of the abdomen, and was centered in a binocular field with its left side up.

A set up of revolving drum, lever, automatic time marker, dry batteries and a Reymond key was used in these in these studies. When the spiracle opened or closed, the circuit was made and broken respectively by manipulating the REYMOND key. Only the activity of the left mesothoracic spiracle of each roach was recorded.

The response of the spiracle of each of these roaches to CO_2 was tested in the following way. A flow of CO_2 was directed on the spiracle until the insect started to kick with its legs. Then, the flow of CO_2 was stopped and the spiracle movements were recorded by the direct observation method until the roach returned to its normal condition. The CO_2 concentration used in the present work was not determined. However, since and increase in the spiracular activity due to CO_2 treatment ensued in almost every case, it follows that dilute concentrations were actually used (KITCHEL and HOSKINS, 1935).

Results

The spiracle of the untreated roaches (Fig. 1, C and D) were either closed or opened most of the time, with sporadic sluggish movements at irregularly long periods. Sometimes, when the spiracles were opened or closed they went into fibrillar movements with their valves slightly moving. However, it was difficult to notice

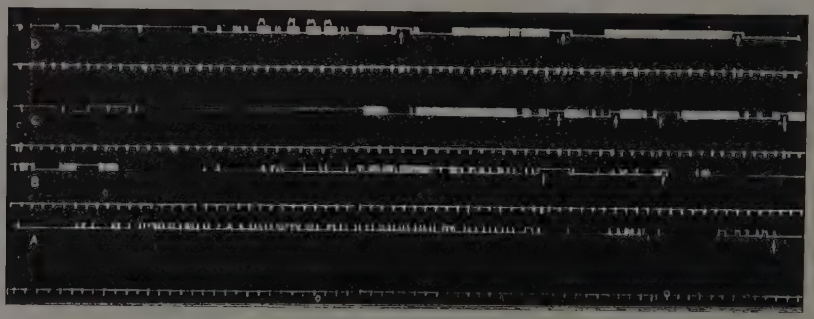

FIG 1 : Records A-D, made each with one roach, show the spiracular activity of the left mesothoracic spiracle of the normal untreated, and lindane treated american male roaches. They also show the response of the spiracles to CO_2, and record D also shows the response of the spiracle to body movements. Time is given under each record, and is the same for all of them (5 seconds).

Legends of the records : A and B records of roaches treated with 0.015 ml. of lindane. C and D records of untreated roaches. Arrows indicate the treatment of the spiracle with a flow of CO_2. M refers to the great increase in spiracular activity due to body movement. Opening of the spiracle is indicated by the downward deflection of the signal marker.

whether they were touching each other or not. After treatment with CO_2, the rate of spiracular movements became faster and then returned gradually to normal rate.

The lindane treated roach closed and opened the spiracle at a fast rate which seemed to be in place with the convulsions of the body (Fig. 1, A and B). The rate of movements was almost regular, it closed nearly twice in every five seconds and that was far less than that of the spiracular movements in the untreated roach as it moved its legs. CO_2 widely opened the spiracles which nearly regained their regular rate as the effect of CO_2 weakened. These results clearly showed that the lindane treated roaches respond to CO_2 differently from the normal roaches.

Discussion

Involuntary movements of the paralyzed appendages of the treated roaches and convulsions of their abdominal muscles, partially or entirely, accounted for the increase in spiracular activity. The sudden burst of spiracular activity due to the leg kicking of the untreated roach (M in record D) is strongly in favour of the above conclusion. It is then evident that by the direct observation method, the net action of the neurotoxin on the respiratory centers and spiracular nerves of roaches can not be studied apart from the action of metabolites (presumably produced by leg kicking) on these centers and nerves.

From the above results, lindane which is a neurotoxin like DDT (Brown, 1951), induced a definite change in the spiracular activity of the American roach and its response to CO_2. These results conform with the observation made by Buck and Keister (1949) on the abdominal spiracles of *Photinus pyralis*. By means of the direct observation method it was observed that the above fly permanently opened its spiracles when it was poisoned by DDT. The above authors could not observe the spiracular activity of *Phorima regina* because its spiracles were minute and difficult to observe.

According to these authors, it was doubtful that the increase in moisture loss when the latter insect was treated with DDT was due to paralysis of the neuro-muscular system controlling the spiracles. However, they did not show experimentally whether this increase in moisture loss was due to the increase in metabolism incurred by the insecticide or by its effect on the neuro-muscular mechanism of the spiracles or both. That increase may also be due to the convulsions of body muscles and other body movements induced by DDT.

It may be concluded from the work of the above authors that :

1. — The direct observation method is impractical for small insects.

2. — The effect of the drug per se on the neuro-muscular mechanism of spiracles can not be separated from the effect of body movements or increase in metabolism on the spiracular activity by that method.

An increase in spiracular activity was clearly noticed on directing the CO_2 flow on the spiracle of the untreated roach. In general, that conforms with results obtained by Kitchel and Hoskins (1935). They pointed out that with 5, 10, and

15% CO_2, the maximum rates of ventilation were 3, 5 and 6 times the normal rate respectively, in air for the Hawaiin roach *Nyctobora noctivaga*. By using 20 and 30% mixtures, tremendous initial increase in ventilation was followed by almost immediate decrease particularly with the higher concentration. Undiluted CO_2 caused an immediate decline in ventilation and no evidence of an initial acceleration was found.

The response of the treated and untreated roache's spiracle to CO_2 is definitely different as is shown in Figure 1. It is evident then, that an atmosphere containing CO_2 is not undesirable should the effect of a neurotoxin on the spiracular activity be studied.

The weak points of the direct observation method and its disadvantages are of prime interest in this paper. Briefly, these disadvantages are :

1. — It depends on the alerthess of the worker and his quick action to follow and record the spiracular movements.

2. — It is impossible to record conveniently the spiracular movements of more than one spiracle at a time. By observing the metathoracic and mesothoracic spiracles of the American roach simultaneously, it was noticed that they moved at different times and at different rates. Thus, the recording of the spiracular activity of all spiracles is unavoidable should a comprehensive study on the spiracular activity of the insect is carried out. Apparently, this is time consuming and tedious.

3. — The rate of movements of one spiracle is liable to variations because the spiracular movement was recorded only after the insect stopped moving and it moved from time to time with different degrees of strength and for varying periods of time. Consequently, the period of closing and opening of the spiracle differed from time to time after the roach stopped moving according to its O_2 need.

4. — The degrees of opening or closing the spiracle can not be recorded by this method; a half opened spiracle will be recorded as a widely opened one. A closed spiracle may leak some gases, especially when it is in slight fibrillar action.

Summary

The effect of lindane on the left mesothoracic spiracle of the American roach was studied by the direct observation method with and without a CO_2 flow hitting the spiracle. The disadvantages of this method pointed out in this paper necessitate finding substitute for the direct observation method to measure the spiracular activity of insects.

II. A LOW PRESSURE METHOD FOR MEASURING SPIRACULAR ACTIVITY OF INSECTS IN TERMS OF TOTAL BODY WEIGHT LOSS

The study of insect spiracular activity by the direct observation method mentioned above, is time consuming, inaccurate and inefficient for quantitative studies. A new and more efficient method that may substitute the direct observation

method, which is currently in use, has been investigated. Briefly, this new method entails measuring spiracular activity in terms of body weight loss under low pressure. To clearify the physiological basis of this method several facts should be considered. It is known that the spiracles account for 60-70% of total moisture loss from the insect's body (SCHEER, 1947). The validity of body weight loss as can index of moisture loss was well established by the work of several authors, e.g. BUCK and KEISTER (1949), and GUNN (1933). Considerations in favour of carrying such experiment under low pressures are :

1. — Under a certain range of low pressures the insects are quiet and hence, the effects of movements on the evaporation rates, and consequently on the spiracular activity are minimized. RAMSAY (1935) estimated the magnitude of the errors induced by hyper-activity of roaches by subjecting them to faradic currents of approximately one second duration at intervals of 10 seconds. The greatest increase in evaporation rate was 100% and the least 58% at 20°C. Eliminating this error results in better reproducibility of the data obtained.

2. — A certain range of low pressures incuces hyperventilation and maximum spiracular activity. Under such conditions, the spiracular nerves function to control the spiracles to protect the insect from desiccation. Slight derangements of the nerve functions will be more obviously reflected in moisture losses than will be the case under normal atmospheric pressure. Undoubtedly, this condition is highly favorable, should the effect of a neurotoxin, such as DDT, on spiracular activity be studied.

High temperatures and high CO_2 concentrations are also known to induce hyper-ventilation. However, high temperature was excluded as a factor that creates the right condition for measuring the spiracular activity because it enhances also moisture loss from the integument (RAMSAY, 1935). Low pressure provides as well, a relatively higher CO_2 concentration because it is the least abundant of gases in the air (N_2,H_2O, and O_2) drawn by the vacuum pump when the pressure is lowered. Obviously, that is because CO_2 has a higher molecular weight than the other constituents of air (SENDERSON, 1953).

3. — At low pressures the insect loses large quantities of moisture in a short period (LUTZ, 1929, LIVINGSTONE and REED, 1940). Therefore, the time required for conducting the experiment is appreciably decreased.

4. — The metabolism is depressed by low pressures (WOODWORTH, 1932). A higher rate of metabolism is expected to be associated with increased rates of spiracular activity, as it is through the spiralces that the increased amounts of O_2, and CO_2 may pass. So, it is probable that metabolic rates affect spiracular activity and they should be depressed to study the net effects of a neurotoxin as DDT (which also increases the metabolic rate) on the nerves controlling the spiracles.

Lastly, facts concerned with tolerance of insects to low pressure should be considered. CARRUTH (1935) found that *Drosophila* could adapt itself to environments containing less than half as much O_2 as the normal atmosphere and still live

and reproduce normally. However, insects can be destroyed by prolonged exposure to low pressures (DARE, 1948, and JOLLOS, 1937). LUTZ (1929) and BOYLE (1760, c.fs WOODWORTH, 1932) have clearly shown that insects are tolerant of very low pressure. if subjected to them for short periods. I believe that the tolerance is partially due to the fact that insects have very low intratracheal pressures. These pressures were measured by MCCUTCHEON (1940), and WATTS (1951). It is not expected then, that the insects tracheae would collapse if they are exposed to low pressures higher than their intra-tracheal pressures (0.6-10 mm. of Hg. for *Schistocerca obscura*). CLICK (1939) collected by an aeroplane wingless and winged insects, with Diptera always leading, from high altitudes (200-5000 ft.). This shows that insects naturally frequent the high altitudes where low pressure prevail.

Materials and methods

Adult roaches *Periplaneta americana* were picked at random from Alexandria sewers. One roach at a time was placed in a flask connected from one side to a mercury open U manometer and from the other to a capillary with a fine drawn end and to a water œump. As the pump evacuates air from the above apparatus, the air enters from the cabillary (Fig. 2) until the pressure reaches a certain low level which depends on the capillary orifice. Pressure is thus regulated at the required level by

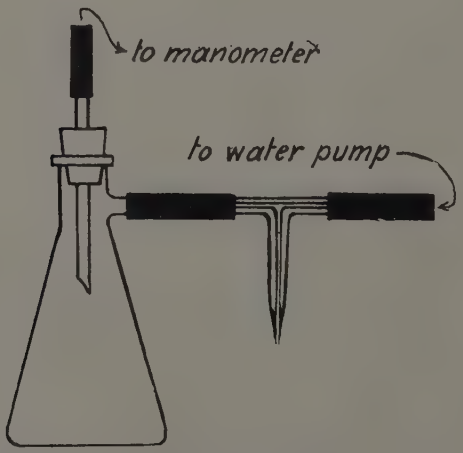

FIG. 2 : Apparatus used for measuring body weight loss of roaches and observing their states of activity under low pressure.

A Buchner flask connected from one side to manometer, and from the other to water pump. A T shaped capillary with drawn fine end inserted between the water pump and flask is used as a vacuustat for controlling the pressure within the flask. All the connections are made with pressure rubber hoses.

increasing or decreasing (by a flame) the orifice. Breaking the capillary tip led to the increase in the orifice and decrease of the pressure obtained.

The above apparatus was used to observe the phases of activity throuah which the roaches pass as the pressure was lowered and to verify the effects of DDT on the spiracular activity in terms of the body weight loss under certain low pressures. These pressures were especially chosen to provide all the possible advantages of measuirng the spiracular activity under low pressures and thus the effects of DDT on the spiracular nerves is ascertained. For carrying such experiment ten DDT treated male roaches, showing different symptoms of DDT posioning (excitement, convulsions or partial paralysis), were used. One roach at a time was placed in the apparatus with an untreated roach. The pressure was then lowered and kept for half an hour at 22-23 mm. of Hg. (the chosen pressure for this experiment). Losses in body weights of roaches during that period were recorded.

To be sure that the roaches spiracles are functional under low pressures, four roaches were put in a 10 mm glass tube with a side arm. As the diameter of that tube is very near to the width of the roache's body, the latter was tightly encased by the tube walls and its thoracic spiracles lend themselves to observation through the glass wall. The tube was connected to the U manometer and the water pump through the side arm, roaches were placed in the tube head to tail, and the tube was tightly stoppered and placed under a binocular. Illumination was indirect from an incandescent lamp, and the spiracles were observed after the roaches got adjusted to the light and stayed quiet under low pressure (56 mm. of Hg.).

Results

1. — *Effect of low pressure on the roaches activity :*

First the roaches moved fast and many of them ran towards the air outlet. By further decrease of pressure the roaches became quiet. It was found possible to keep the roaches quiet for 1/2 an hour, if the pressure was kept constant at that level (55, 56, 57, 63, and 80 mm. of Hg.). This observation was of major importance because it made it clear that spiracular activity could be measured under low pressures without errors due to movement of insects. At that stage irregular respiratory movements were also noted and were increased by a further decrease in pressure. However, when the pressure was kept constant, fewer respiratory movements were observed. By a further decrease in pressure the roach suddenly burst into action and turned over its back working its legs and apparently struggling for air. The pressure at which maximum excitation occurred averaged 42 $\pm$ 3.7 mm. of Hg. This stage lasted for 30-50 seconds and ended in convulsions with the body stretched out. Convulsions lasted for about 20-30 seconds and were followed by stupefaction. The average pressure at stupefaction was 7.8 $\pm$ 3.6 mm. The above figures are based on experiments carried on fourteen different roaches.

2. — *Observation of spiracular movements under low pressures*:

Spiracles were observed after the roaches got adjusted to light and stayed quiet under a low pressure (56 mm.). The spiracles were found to open and close at intervals much shorter than observed under normal atmospheric pressure. After about 5 minutes transpired moisture accumulated on glass and made vision impossible.

3. — *Verification of the method of measuring spiracular activity in terms of body weight loss under low pressure :*

It is clear from part 1 of the results that any pressure to which the roaches become adjusted and stay quiet is suitable for measuring the spiracular activity or the effect of light on the spiracular activity (WIGGLESWORTH, 1950). Unfortunately, those pressures are unfavorable when measuring the effect of DDT because the DDT treated roaches did not stay as do the untreated ones at the above pressures. To minimize errors introduced by differences in activity between DDT treated and untreated roaches they were subjected to a rapid decompression to stupify in very few seconds. The pressure should then be kept constant at any value below 42 mm. that seems to be right for studying the roaches spiracular activity (e.g. 21-23 mm.). This pressure has to be reached as fast as possible even if it is necessary to use a two stage vacuum pump. The pressure of maximum excitation was not chosen for testing the DDT effects because it varied from 32-46 mm. and the roaches especially the DDT treated were exhausted and stupefied very soon.

The maximum difference in the rate of body weight loss of the DDT treated and the untreated roaches was 0.63 and 0.31 mg./gm./min., respectively, and, the average was 0.52 and 0.46. The pressure 21-23 mm. then, seems to be promising for conducting further experiments because all the roaches lose measurable water under that pressure and the treated roaches lost more than the untreated ones.

Discussion

The changes in the roach activity with the decrease of pressure observed in these experiment was in accord with UNDERHILL's (1940) and WELLINGTON's, 1945) observations. By using a different technique, WELLINGTON noticed that the flight activity increased with Dipterous and Coleopterous experimental insects up to an altitude of 1.46 km. where it again approached normality. To prove that such activity was due to low pressures per se and not to the decrease in O_2 or CO_2 partial pressures, the pressure in the insect chamber was lowered to 890 millibar. Nitrogen was then introduced until the air pressure became normal. Under such conditions the insects did not maintain the flight activity although the O_2 and CO_2 were in such quantities as those found at the low pressures. It was general for all insects tested that after 8-10 km. of altitude, flight activity decreased until the minimum flight pressure was passed. The minimum pressure differed from one species to another

and after that pressure the insects could still move their appendages. Before they became insensible and lost their footing there was a sudden activity.

UNDERHILL (1940) also noticed that the decrease in pressure stimulates the feeding activities of simuliids on turkeys. The more rapid the change the greater is the effect on the flies.

In all the above experiments and those that will follow, roaches that were once subjected to low pressure were not used again in any other experiment. According to STEMLAR et AL (1951), re-exposure of roaches to low pressures may give results in the moisture loss different from those of the first exposure to the same range of low pressures. They found that larvae and adults of five insect orders acquired tolerance to anoxia inflicted by decompression, by subjection to N2 atmosphere or by submergence in water, house-flies retained the acquired tolerance for 48 hours.

It was shown by the direct observation method that neurotoxins, such as DDT or lindane, increase the spiracular activity (BUCK and KEISTER, 1949), (see in Part I of this paper). To test the method of measuring spiracular activity under low pressures, the total body weights losses from untreated and DDT treated roaches were measured gravimetrically by the method developed in this paper. In spite of the fact that the loss rates from treated and untreated roaches were inconsistent and differed significantly from each other in some experiments, the difference in the average loss is apparently small. That was attributed to the fact that no precautions were taken to eleminate some variables. Such variables were type of the food the roaches lived on, moisture content near the terminals of their digestive tracts, body temperature during the expt. and age of roaches. Therefore, the results of testing the low pressure method by showing the expected differences in body weight losses of untreated and DDT treated roaches, were indicative but not conclusive.

The pressure 22 ± 1 seems to be promising for conducting further experiments because all the roaches lost measurable weights under that pressure and the treated roaches lost more than the untreated ones.

Probably, the total loss in the body weight was entirely or partially due to the moisture evaporation from the spiracles, the body surface and the openings of the digestive tract. The differences in the diameters of the digestive tract's openings undoubtedly, contributed to the inconsistancy of the results. That variable will also be taken care of in future experiments.

Lastly, reasons for neglecting the common method of measuring moisture loss under atmospheric pressure should be given. That method employed by GUNN (1933), and BUCK and KEISTER (1949) for measuring moisture loss in terms of total loss in body weight of insects after 2 hours exposure to $H_2 SO_4$ vapours, was found inadequate for the purpose of the present study. Losses due to defecation, hyperactivity of DDT treated roaches and respirable solids were added to the moisture loss from integument, spiracles and other body openings.

Summary

Certain low pressures minimize the metabolic rate, shortens the experimental period and reduces the activity of roaches. As low pressures induce hyper-ventilation and the spiracular nerves exert maximum control on the spiracles under such condition, any slight effects of any neurotoxin on the nerves may be clearly reflected by the changes in the moisture and body weight losses (if certain variables controlled).

Studying the spiracular activity under low pressures by the direct observation method proved impractical because of the difficulty in focusing on the spiracles and the fast accumulation of transpired moisture on the glass which renders vision unclear.

A simple apparatus was especially designed for studying the effects of different low pressures on the activity of roaches in order to choose the right pressures for carrying out the experiments on the measurement of spiracular activity of roaches. The average pressure or maximum excitation of randomly pickeds roaches as found by the apparatus was 42 $\pm$ 3.7 and the average pressure of stupefaction was 7.8 + 3.6 mm. of mercury. The same apparatus was used to prove that a pressure of 21-23 mm. was suitable for studying the effect of DDT on body weight loss of randomly picked roaches.

ACKNOWLEDGMENT

I am particularly grateful to Dr. Ahmed Abdel-Gawad Hassan, head of the Entomological Department, Faculty of Agriculture, Ein-Shems University; to Mohamed Soliman El-Zoheiry, ex-Director and Chief Entomologist of the Plant Protection Department, Egyptian Ministry of Agriculture; to Dr. Hussein Zaazou, Professor of Entomology; and to Dr. Abdel-Latif El-Deeb. Their help made the present work possible.

Thanks are also due to Profs. Drs. Hamed Seleem Soliman and T. Dobzhansky, for their criticism during preparation of the manuscript, and to the Department of Entomology (University of Massachussetts), for providing material, equipments and technical help for carrying out experiments of Part I.

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ON THE BIONOMICS AND CONTROL OF THE BEAN-FLY, *AGROMYZA PHASEOLI* COQ.

[*Diptera* : *Agromyzidae*]

(with 2 Tables)

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Agromyza phaseoli was recorded in Gizah by HASSAN (1947). It is actually distributed all over the country, from Aswan to Alexandria, and infests all kinds of beans, and lobia (*Dolichos sequipedalis*) to some extent. Beans cultivated in the late summer "Neely", are mostly kept as dry crop, and are seriously attacked by the pest.

BIOLOGY

The female deposits its eggs underneath the epidermis of the lower surface of the compound leaves. The attack starts as soon as the first vegetative leaf appears, i.e. within three days after the plants start to show above the ground. The attack continues after the formation of the seeds.

Newly hatching larvae burrow in plant tissue, forming minute mines between the two surfaces of the leaf; they move slowly towards the leaf stalk, then they tunnel down to the base of the main stem. During their journey, they feed on the plant tissue until they reach the ground surface where they pupate. In older plants, where the distance between leaves and the ground level is longer and harder because of the increase of fibrous tissue in the plant, pupation occurs on any level in the stem, in the branches or in the leaf stalks, specially on the fleshy joints which become more stout than usual. Sometimes the larva cannot even exceed the fleshy joints of the leaflets.

The mines are formed by the larvae as they attack the cortical cells just underneath the epidermis of the plants, which then look transparent. These mines are the most prominent symptoms of infestation.

When the attack is severe, specially in young plants, the cortical cells of the stem are seriously ruined, the plants become yellow in appearance and commence to wither. The leaves are shed, and the whole plant may die gradually. When the attack is slight, the stem becomes blistered and calloused, but that does not stop flowering or seed formation, although the yield is probably affected quantitatively and qualitatively. The secondary tissue "callous" usually renders the plants susceptible to wind damage and breakable by farmer's daily work.

The newly developed pupae are yellowish in colour, 3 mm. long, 0.15 mm. wide; the colour is transferred to deep brown gradually. Pupae are to be found within the plant tissue, or in the soil when such tissue is so attacked that it cannot uphold them. After collecting the crop, the vegetative parts, usually, contain numerous pupae. Some of these plants were brought to the laboratory; almost one third of the pupae within succeed to produce adults. A cooperative campaign to exterminate such plants would help to keep this pest under check to some extent in the following season.

The insect usually passes winter time as pupae hiding within plants, or as adults under shelter; however, diapause was never observed.

The adult passes the whole day in the fields of beans. In the early morning and late in the afternoon, flies hover in good number over plants and fly between leaves. Many cases of copulation are usually observed. At noon, the adults usually hide between the leaves and branches of the plants avoiding direct sunrays. With the help of its telescopic styloid ovipositor, the gravid female makes more than one puncture searching for a suitable area on the leaf before eggs are deposited. The female usually embibes the exuding sap of these punctures with the proboscis; these observations were also recorded by HERING (1947) on leaf-miners. Since both sexes stay in fields during the whole day, the insect body is in direct contact with the residues of insecticides. However, the female habit of embibing the exuding sap might be an activity by which flies are more susceptible to residues.

It was noticed that light traps are useful for the daily catch of adults; this may help to study the population all over the year and to detect the peak of generation. Preliminary observations between October and April 1955, has showed that the lowest population occurs between the end of November and the end of March, that there is a fantastic daily fluctuation which is probably due to variation in microclimatic conditions, that ordinary electric light attracted the adults up till 170 feet high, and that ordinary electric light is far much efficient than the infra-red light.

A preliminary experiment was carried to find out the degree of the natural resistance of the following plants against the pest : Monte-calm, Swiss blanc, and Contender. These plants were kept in cages, and newly emerging adults were introduced into them, but flies failed to copulate or lay eggs in captivity. Gravid females were then introduced, and all plants were seriously attacked, showing that these common kinds of plants are highly susceptible to the attack.

In October 1955, a serious infestation was recorded on Soy-beans, in Giza and Alexandria; the same infestation was also noticed during the same time and on larger scale, in 1956. This was due to a fly which is rather similar to, but definitely not *Agromyza phaseoli*, because the former is slightly bigger and different in the venation of wings and distribution of bristles on the body than on the later. This pest, however, attacks the leaves and the larvae end in the young stem; in the full grown plants pupae do not exceed the base of the leaves.

CONTROL

1. — In Australia, plant breeders produced many resistant strains of beans against *Agromyza phaseoli*. It is highly recommended that such strains should be imported and experimented in this country, and that a breeding program should be executed to produce resistant strains under our own conditions.

2. — In the chemical control of the bean-fly, timing seems to be of the utmost importance. The pest starts attacking the plants when they commence to show above the soil. Providing that the eggs hatch within three days (MORGAN, 1938), it should be kept in mind that plants "neely" should be sprayed by that time, since most of the damage is due to the attack of young plants.

An experiment has been designed at Dokki Vegetable Experimental Station, to compare the effect of some newer insecticides, as a measure of control against *Agromyza phaseoli* (cultivation on 17.ix.1954 and treatments as in Table I). Blocks were distributed in random (C, G, E, A, D, B, F; F, D, C, B, E, G, A; B, F, A, G, C, E, D; E, C, G, D, F, A, B). Each block was divided into two parts, one cultivated with Swiss blanc, the other with *Phaseolus mungo* which was recom-

TABLE I

List of chemicals used and their spraying schedule.

Treatments	Intervals between successive sprays in days	Number of sprays	Insecticides technical ingredients
A	12	4	Diazinon 9/10000
B	12	4	Diazinon 9/10000 + DDT 2/1000
C	10	6	DDT 2/1000
D	12	4	DDT 2/1000
E	10	6	Chlordane 3/1000
F	12	4	Chlordane 3/000
G	—	—	Control

TABLE II

Analysis of different treatments.

Type	A	B	C	D	E	F	G	Total
Swiss blanc old * ..	46.51	59.55	124.90	69.89	61.92	24.03	146.08	532.88
Swiss blanc new ** ..	130.01	126.96	111.44	143.46	43.59	196.68	167.06	919.20
Phas. mungo old* ...	99.91	47.65	136.06	142.45	16.66	34.18	76.00	552.91
Phas. mungo new * ..	111.51	66.14	56.67	97.86	49.10	174.06	101.12	656.45
Total	387.94	300.30	429.07	453.65	171.27	428.95	490.26	2661.44

* = pest attack before flowering; ** = pest attack after flowering

mended to be resistant to the attack of the pest. Table II gives the analysis of the experiment. Treatment can be listed in the following order providing L.S.D. = 124.53. G 490.26, D 453.65, C 429.07, F 428.95, A 387.94, B 300.30, E 171.27.

It would be concluded that there is a significant variance between the treatment E and other treatments, and a significant difference between B and F, C, D, and G, which are similar between each other. There is no difference between B and A. Chlordane and then Diazinon are to be recommended for the control of the fly. However, the least population of the red mite after control was noticed with the use of Diazinon. Chlordane is not recommended for beans as green crop because of hazards. In another experiment these informations were confirmed; moreover, parathion ($2^0/_{00}$ technical ingredient) proved to be also satisfactory, but definitey is inferior to Diazinon, Chlordane or Chlordane + Diazinon.

ACKNOWLEDGMENTS

The author is deeply grateful to his colleague SALAH BAHAELDIN for kind help in statistical analysis.

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THE RELATIVE TOXICITY OF CARBON DISULPHIDE TO THE DIFFERENT LARVAL INSTARS AND PUPAE OF *CORCYRA CEPHALONICA* STAIN. AND *EPHESTIA KUEHNIELLA* ZELLER

[*Lepidoptera* : *Pyralidae*]

(with 15 Text-Figures and 3 Tables)

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CONTENTS

I. Introduction. — II. Materials and methods (1. Rearing the insects; 2. Fumigation chamber; 3. Measurement of doses and introduction of fumigant; 4. Fumigation technique; 5. Treatment of insects after fumigation; 6. Estimation of mortality; 7. Experimental design and analysis of data). — III. Results (A. The larvae; B. The pupae). — IV. Discussion. — V. Summary. — VI. Acknowledgments.— VII. References.

I. INTRODUCTION

Stored food products are subject to attack by different insect pests belonging mainly to orders Lepidoptera and Coleoptera. The mediterranean flour moth, *Ephestia kuehniella* Zell., and the rice moth, *Corcyra cephalonica* Stain., are by far the most important Lepidopterous pests that attack grain products throughout the world.

Up to the present time, fumigation has been the only practical method used for combating these pests. Many fumigants have been used, of which carbon disulphide is commonly used in Egypt. It is used in the fumigation of grain and grain products both inland and in the quarantine stations at the ports.

The development of satisfactory methods of fumigation depends on a great variety of factors of which the most important are : toxicity of different fumigants to different insect pests, taking into consideration the variations that might occur between and within the different stages of any given species, penetration of the fumigant, damage to goods by tainting, formation of poisonous compounds and loss of dietetic value.

In this work, a fairly detailed study of the relative susceptibility of the different larval instars and pupal stages of *Ephestia kuehniella* Zell. and *Corcyra cephalonica* Stain. to fumigation with carbon disulphide has been carried out. Also studies on the variation of susceptibility due to age within the larval instars and the pupal stage were done. Two arbitrary points in the development of each larval instar and the pupal stage, i.e. immediately after moulting and just before the next moult, were selected and the susceptibility was determined at these two points.

It is important for the purposes of practical control, that some knowledge should be available on this subject in order to assess the likelyhood of resistant stages being present and their effect on the efficiency of practical control. This information will also assist in determining the correct time and method of application.

II. MATERIALS AND METHODS

1. Rearing the insects

A. Food material

The larvae of both *Corcyra cephalonica* Stain. and *Ephestia kuehniella* Zell. live and feed inside cocoons. These cocoons are supposed to be only for the protection of the larvae against the particles of the food materials, and are not expected to hinder the exchange of gases. Nevertheless it was thought advisable to do all the tests of larvae without cocoons in order to eliminate any factor that might prevent the full exposure of the larvae to the fumigant. On the other hand free larvae are easy to handle, to be examined and are thus most suitable for the purpose of this work. Some trials were made in order to prevent larvae from building cocoons (see Azab, 1954) but were found inconvenient in supplying enough numbers of larvae daily. This difficulty was overcome by trying different food materials for rearing the experimented insects. Wheat bran was found satisfactory for this purpose; most of the larvae reared on this diet lived without cocoons throughout their life. Other food materials tried were whole meal flour, whole maize flour, crushed maize, polished rice flour and whole rice flour. With the rice flour, it was also possible to obtain sufficient numbers of free larvae, but the rate of mortality was very high. With whole maize flour, a high percentage of larvae also developed without cocoons.

B. Cultures

150-200 eggs obtained from newly emerged adults from cultures reared on wheat bran, were transferred to one pound jars half full with wheat bran. These Jars were then covered with muslin and kept in an incubator running at 28 °C. ± 0. 0.5 and 60-70% relative humidity. Enough jars to supply the required daily numbers of larvae from different instars were kept continuously.

C. Selection of larvae

Because the toxicity work usually needs considerable numbers of test insects in order to obscures day to day variation in resistance of individual insects, choosing the required larvae in different ages by timing their moults was found impracticable. It was decided, therefore, to try a quicker technique by which this difficulty could be overcome. After long experience in rearing the two species, especially that a rairly detailed study on the biology of one of them, *Corcyra cephalonica* Stain., had been carried out before the start of this toxicity work, the writers were able to differentiate between the different instars by size. Also the variation in size within any given instar was so clear that it was easy to distinguih at least between the sizes of the larvae after moulting and before the next moult. Therefore, a method of selection according to variation in size was followed throughout this work. Two standard sizes were chosen within each larval instar, the first size representing the start of the instar, and the second representing its end. This technique of sizing was also adopted by other workers for similar studies such as TUMA (1938), YOSIDA (1948) and MUKERJEA (1953).

The technique followed in separating batches of larvae was as follows :

Larvae of any given size were isolated by the use of a small brush from different jars of a same starting date until enough numbers were obtained. A further isolation was then carried out to ensure that all the larvae were excatly of the same size.

The isolated larvae were transferred in batches into glass tubing of one inch diameter and 2 inches long, covered with muslin at both ends. This size of glass tubing was quite enough to accomodate 30 larvae of the first to the third instars, but only 15 of the fourth to the sixth instar larvae could be put in each without being crowded. Throughout the whole process of preparing the larvae for fumigation experiments, great precaution was taken to avoid injuring them.

D. Selection of pupae

In the case of pupae, cocooned and uncocooned individuals were used. The uncocooned pupae were examined when 2 and 7 days old. The cocooned pupae were examined only when 2 days old. The following method was found suitable and convenient for obtaining the pupae at the required ages : last instar larvae transforming to the prepupal stage were collected from the culture jars and transferred in threes to glass tubes, 1 × 3 inches. It was easy to collect the larvae of *Ephestia kuehniella* Zell. in the prepupal stage, because the larvae in this age usually crawl

up to the muslin cover of the jar to pupate. But *Corcyra cephalonica* Stain. larvae rarely pupate outside the food material and therefore they were chosen by feature.

A sufficient number of these prepupae were prepared continuously for every day work. They were kept in the incubator under the same conditions of the cultures. The prepupae were watched carefully and the pupation time was registered on each tube. The larvae pupated on the bottom and sides of the tubes or beneath the muslin cover. The side of the cocoon adherent to the glass wall was very thin and transparent, that the pupae could be taken out of the coccons without been injured.

2. Fumigation chamber

Pyrex aspirators of about 5 litres capacity were used as fumigation chambers. The exact capacity was determined by filling each one with water. The two openings in each aspirator were stoppered with rubber bungs, thoroughly wrapped with two layers of tin paper to prevent direct contact with the fumigant. To assist distribution of the fumigant in the chamber, a glass rod inserted through the top stopper, and to which a disk of tin paper was attached, was moved up and down several times at the beginning of the fumigation and at occasional intervals during the exposure period. This glass rod was also used for breaking the glass ampoule containing the fumigant as will be described later.

3. Measurement of doses and introduction of fumigant

The gas was introduced by using an ampoule containing a weighed amount of the fumigant. The technique of making and filling these ampoules is described by LUBATTI (1935) and TURTLE (1941). A one ml. micro-burette was used for filling the ampoule to the nearest volume of the liquid fumigant and then the quantity was adjusted to the required weight by adding more fumigant or by taking some by the use of a very fine drawn piece of glass tubing. By this method, it was possible to adjust the weight to the nearest 0.5 milligram, and the inaccuracy involved here could be considered negligible, since it amounts only to 1% in the lowest dose used and to about 0.2% in the highest dose. After filling and adjusting the weight, the ampoules were sealed by the use o a very fine flame and then kept until required.

4. Fumigation technique

The glass chambers, before use for each fumigation experiment, were kept and left unstoppered for about 24 hours in an incubator at the same conditions of temperature and relative humidity standardised for the fumigation experiments. This precaution was taken in order to ensure that the relative humidity inside the fumigation chamber does not vary from the relative humidity of the rearing atmosphere, and also to keep this factor at a constant level in all the experiments. Although this precaution was taken, the results of other workers such as BRINLEY and

BAKER (1927) and LINDGREN and SHEPARD (1932), indicate that over a wide range, relative humidity has little effect upon resistance of insects to fumigants.

The glass tubing containing the larvae or pupae were let inside the fumigation chamber, together with the glass ampoule containing the fumigant, and then the chamber was stoppered. The glass ampoule was then broken by the aid of the glass rod inserted through the top stopper. As mentioned before, this glass rod, to which a disk of tin paper was fastened, was moved up and down many times to help distributing the gas evenly. The chamber is kept in an incubator at 28:C. $\pm$ 0.5 for the whole period of exposure, with occasional mixing of the gas. At the end of the fumigation period, the chamber was taken from the incubator, opened and the tubing containing the tested insects taken out. The period of exposure in all the experiments was four hours.

The fumigant used in the present work was stated to be chemically pure. A sufficient quantity of the same liquid fumigant was kept in a glass bottle with a well fitted glass stopper ready for use throughout the whole period of the experiments. The dosages were calculated on the basis of the cubic content of each fumigation chamber, assuming that the loss through the sorption of gase by the walls of the fumigation chamber is very low.

5. Treatment of insects after fumigation

Immediately after removal from the fumigation chamber, the first to the third instar lavae were transferred to glass sampling tubes 1×3 inch containing wheat bran as food, 30 in. each tube. Thirty larvae of the 4th. to 6th instars or 30 pupae were transferred to one pound jars containing also the same food.

6. Estimation of mortality

Mortality counts of the larvae were carried out on the 6th. day after fumigation and on the 9th. day for the pupae. These periods were found to be enough for the larvae to get transformed to the next instar or pupal stage and for the pupae to develop into adults under the stated controlled conditions. The criterion of effect followed in this work was the complete success or failure of the larvae or pupae to develop into the next stage. Control treatments were carried out in the same way as in the fumigation experiments and rate of mortality was also determined by the same manner. A correction was then made by estimating the true kill using ABBOT'S formula :

$$\text{True kill} = \frac{100\ (X\text{-}Y)}{100 - Y}$$

where X = observed percentage kill and Y = control deaths.

7. Experimental design and analysis of data

The experiments were designed to provide concentration mortality regression lines for each larval instar of both species in a period of exposure of four hours under atmospheric pressure and at 28°C. Two regression lines were made for each larval instar, one line showing the effect at the beginning of instar and the other showing the effect at the end of same instar. For the pupae, three regression lines were made, two for the uncocooned, when 2 days and 7 days old, and the third regression line for the cocooned when 2 days old.

Preliminary experiments were necessary at the beginning to determine the dosage range that gives mortalities between 20% and 90% for each case separately. Then a series of experiments follow to cover a number of points, varying from 5-11, within this range of mortality. Every determination was repeated four times and the average taken as the final result for use in the statistical analysis. In other words every point in the regression lines is the mean of four determinations.

The percentage responses of each determination, after correction for any control responses using ABBOT's formula, were converted into their probits, FISHER and YATES (1948). Dosage mortality were plotted for probit logarithmic transformation for each case studied. Then the slopes of the probit lines, the 50 and 95% lethal doses (LD 50's and 95's) were estimated by the probit method of analysis.

Following this experimental design a considerable number of larvae and pupae was needed. In the case of *Corcyra cephalonica* Stain., the following numbers were needed : 1st instar, 1080; 2nd instar, 1440; 3rd instar, 1440; 4th instar, 1680; 5th instar, 1440; and 6th instar, 1560. The total of all larvae used was 8,640. In the case of *Ephestia kuehniella* Zell., the numbers were 1560, 1560, 1920, 2040, 1940, 1920 and 1920 respectively, and the total was 10,290. As mentioned before, the batch used for each determination was 30 and each determination was repeated 4 times. In other words, 120 individuals were used to indicate each point in any one of the regression lines.

As regards the pupae, 2040 uncocooned and 1320 cocooned pupae of *Corcyra cephalonica* Stain. and 2400 uncocooned and 1320 cocooned pupae of *Ephestia kuehniella* Zell. were needed. The total number of pupae for the two species was 3720. Nearly the same number of larvae and pupae was used in the control treatments.

The experiments were conducted in random order so as to avoid introducing a temporal bias into the mortality determinations due to any possible changes in the tolerance level of the larvae and pupae throughout the whole period of the work. According to PAGE (personal communication), work by BLISS and unpublished work done at the Imperial College Field Station, London, by DATTA GUPTA have demonstrated that resistance has two components which are of different magnitude in different species. One of these components, long term resistance, is inherent in the individual insect and the other, short term resistance, varies from occasion to occasion of testing. As has been mentioned before, the day to day variation in resistance of individual larvae and pupae has been to a large extent obscured by the large size

of the total numbers used. In order to obscure the effect of variation due to change in long term resistance, the order of experimentation was randomised.

III. RESULTS

The results are plotted graphically in Figures 1 to 7 and Figures 8 to 14 for *Corcyra cephalonica* Stain and *Ephestia kuehniella* Zell. respectively. Tables I and II include the regression equations, the LD50 s, the LD95s and the slopes of the regression lines for the two species.

The number of determinations of each case studied is equal to the number of degrees of freedom (shown in column 4 of Tables I and II) plus two (one of these two has been used up to fix the position and the other to fix the slope of the regression line). In the probability column, the level of P (indicated by asterisks) gives a measure of the adequacy of each regression line as a representation of the data, and also a measure of the uniformity of the tested insects.

A. The larvae

1. Shapes and slopes of probit lines

For most of the cases studied, toxicity tests gave a series of points through wich straight regression lines could be drawn. In few cases, upon fitting the best straight line, there was some evidence of curvature. All the lines drawn in the figures are those calculated from the regression equations.

On studying the slopes of each series of regression lines the following conclusions could be deducted (see Tables I and II).

Corcyra cephalonica Stain.

1. — Excluding the first instar (Fig. 1) for which the data are in some ways unsatisfactory, there is nearly no significant difference between the slopes of the regression lines for the two sizes of larvae tested in each instar.

2. — Also excluding the 1st instar larvae, there appears to be a tendency for the slopes to fall slightly from the second to the third instar and then to rise again as the instars proceed.

Although these changes in the slopes of the regression lines may be due in some way to experimental error or method or are in some way bound up with the double transformation probit method, yet there may be a direct connection between the change in slope and the nature of the organisms under test. Differences in slopes of regression lines were observed by workers studying the effect of a given insecticide on different organisms. LORD (1948), obtained different relative slopes for DDT. compounds when these were tested against two different types of organisms. BUSVINE (1938), in his work on the toxicity of ethylene oxide, found out that the slopes of

TABLE I

Regression equations and 50% and 95% kill doses of the different larval instars and pupal stages of Corcyra cephalonica.

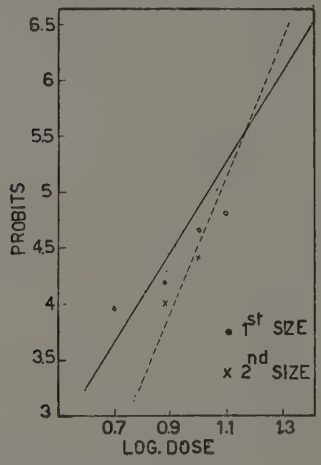
Instars		Regression equation Y = Probits X = Log. conc.	Slope of the regression line	Degrees of freedom	t	Probability P 0.05* P 0.05** P 0.01***	50% kill dose in mg./l.	95% kill dose in mg./l.
Larvae								
First instar	First size	Y = 4.0788 X + 0.8160	4.0788	3	3.022	non significant	10.61	26.79
	Second size	Y = 6.1327 X — 1.5696	6.1327	2	3.26	non significant	11.79	21.81
Second instar	First size	Y = 5.4284 X — 0.9148	5.4284	4	7.085	***	12.29	24.64
	Second size	Y = 5.3918 X — 1.1140	5.3918	4	6.270	***	13.61	27.43
Third instar	First size	Y = 5.1367 X — 0.6595	5.1367	4	5.380	***	12.64	26.36
	Second size	Y = 5.0484 X — 0.7310	5.0484	4	4.080	significant (5%)	13.66	28.85
Fourth instar	First size	Y = 6.2713 X — 2.3548	6.2713	5	12.057	***	14.80	27.18
	Second size	Y = 6.0937 X — 2.3575	6.0937	5	18.289	***	16.12	29.95
Fifth instar	First size	Y = 6.3256 X — 2.4985	6.3256	4	9.720	***	15.32	27.84
	Second size	Y = 7.8383 X — 4.6357	7.8383	4	22.437	***	16.95	27.45
Sixth instar	First size	Y = 6.5879 X — 3.0029	6.5879	5	14.137	***	16.40	29.09
	Second size	Y = 7.1299 X — 3.9022	7.1299	4	10.123	***	17.72	30.09
Pupae								
Uncocooned, 2 days old		Y = 3.8661 X + 0.0372	3.8661	7	8.770	***	19.22	51.04
Uncocooned, 7 days old		Y = 3.8995 X + 0.4925	3.8995	6	9.730	***	14.32	37.71
Cocooned, 2 days old		Y = 4.0816 X — 0.5151	4.0816	9	8.890	***	22.45	56.62

TABLE II

Regression equations and 50% and 95% kill doses of the different larval instar and pupal stage of Ephestia kuehniella.

Instars		Regression equation Y = Probits X = Log. conc.	Slope of the regression line	Degrees of freedom	t	Probability P 0.50* P 0.50** P 0.01***	50% kill dose in mg./l.	95% kill dose in mg./l.
Larvae								
First instar	First size	Y = 0.0517 X — 0.7254	5.0517	5	10.627	***	13.59	23.71
	Second size	Y = 6.5364 X — 2.8503	6.5364	4	15.626	***	15.89	23.31
Second instar	First size	Y = 5.6562 X — 1.9221	5.6562	5	17.711	***	16.74	32.61
	Second size	Y = 6.2187 X — 2 9930	6.2187	4	9.065	***	19.29	25.40
Third instar	First size	Y = 6.1007 X — 2.8144	6.1007	6	11.936	***	19.09	35.46
	Second size	Y = 5.5683 X — 2.4367	5.5683	6	15.1942	***	21.65	42.67
Fourth instar	First size	Y = 6.5380 X — 3.8788	6.5380	7	17.222	***	22.80	40.62
	Second size	Y = 6.1441 X — 3.5327	6.1441	6	23.873	***	24.47	45.25
Fith instar	First size	Y = 9.0772 X — 8.4346	9.0772	6	14.262	***	30.20	45.70
	Second size	Y = 9.0022 X — 8.5895	9.0022	6	18.105	***	32.32	49.17
Sixth instar	First size	Y = 9.0662 X — 8.7369	9.0662	6	17.192	***	32.74	49.66
	Second size	Y 9.3076 X — 9.3621	9.3076	6	13.098	***	34.91	52.38
Pupae								
Uncocooned, 2 days old		Y = 6.2417 X — 4.1319	6.2417	9	12.596	***	29.04	53.18
Uncocooned, 7 days old		Y = 5.8321 X — 3.3334	5.8321	7	7.872	***	26.85	51.30
Coconed, 2 days old		Y = 6.3582 X — 4.4065	6.3582	9	13.305	***	30.16	54.62

the regression lines behaved differently for the four different organisms he used. So it could be stated here that the differences observed in the slopes of the regression lines of the different larval instars of the two species in hand, might be due to changes in the responses of these larvae, acting if they were different organisms.



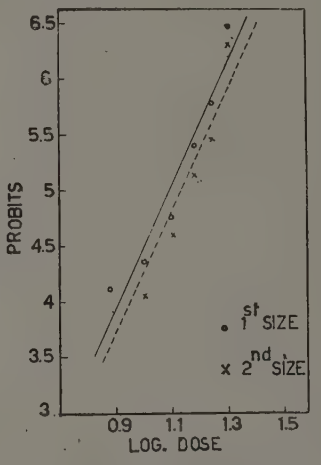
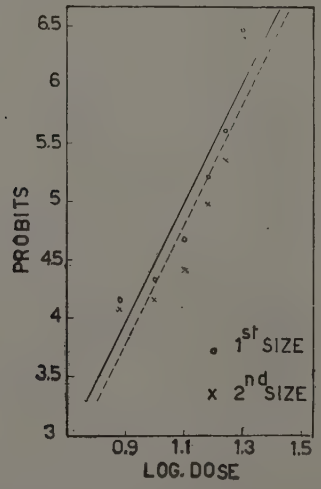


FIG. 1 (left): Dose kill regression lines for the first larval instar of *Corcyra cephalonica* Stain. — FIG. 2 (right) : Dose kill regression lines for the second larval instar of *Corcyra cephalonica* Stain



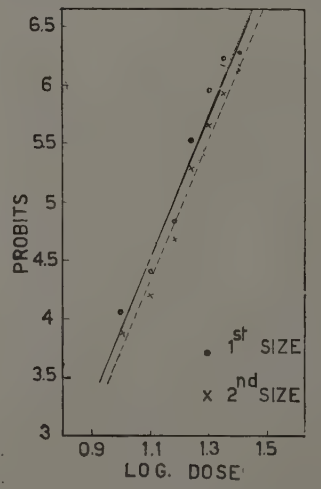


FIG. 3 (left): Dose kill regression lines for the third larval instar of *Corcyra cephalonica* Stain. — FIG. 4 (right) : Dose kill regression lines for the fourth larval instar of *Corcyra cephalonica* Stain.

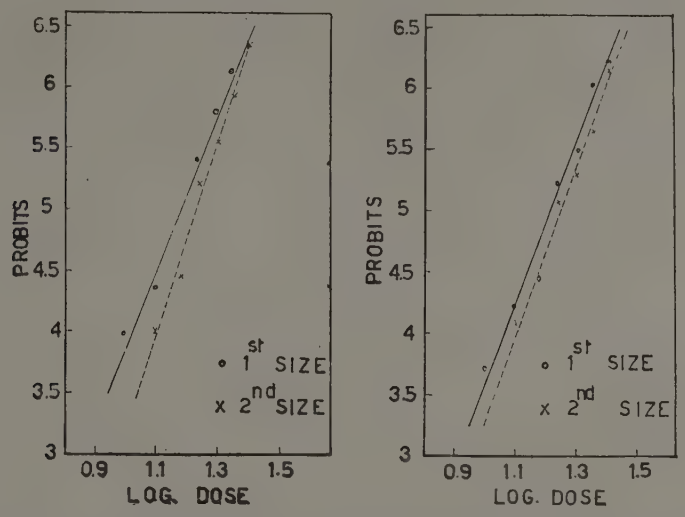


FIG. 5 (left) : Dose kill regression lines for the firth larval instar of *Corcyra cephalonica* Stain.— FIG. 6 (right) : Dose kill regression lines for the sixth larval instar of *Corcyra cephalonica* Stain.

Ephestia kuehniella Zell.

In the first instar only (Fig. 8), there is a significant difference (probability 0.05) in the slope of the two sizes studied, the slope of the second size being higher. There appears to be a tendency for the slopes to be nearly the same in the 2nd. to

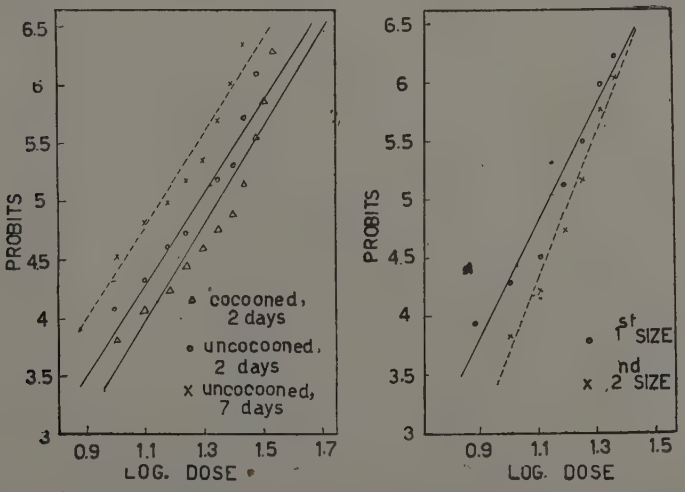
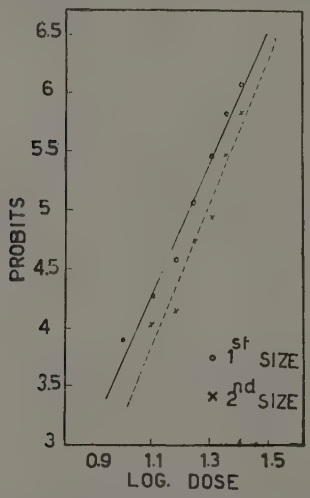


FIG. 7 (left) : Dose kill regression lines for the pupal stage of *Corcyra cephalonica* Stain. — FIG. 8 (right) : Dose kill regression lines for the first larval instar of *Ephestia kuehniella* Zell.

the 4th. instars, and then a considerable increase occurs in the 5th. instar. The difference between the slopes of the regression lines of the 1st. size of the 4th. and 5th. larval instars was found to be significant at the 1 % level of propability. Again there is no significant difference between the slopes in the 5th. and 6th. instars.



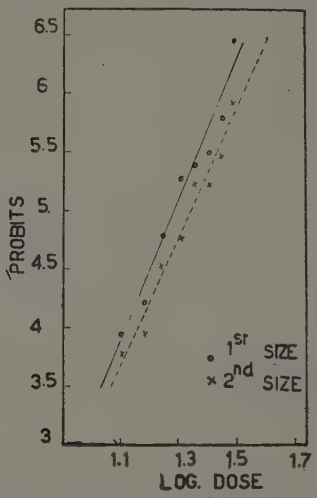
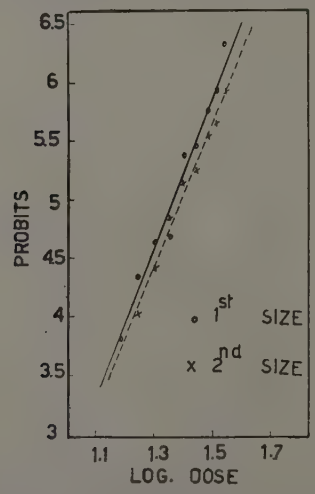


Fig. 9 (left) : Dose kill regression lines for the second larval instar of *Ephestia kuehniella* Zell. — Fig. 10 (right) : Dose kill regression lines for the third larval instar of *Ephestia kuehniella* Zell.



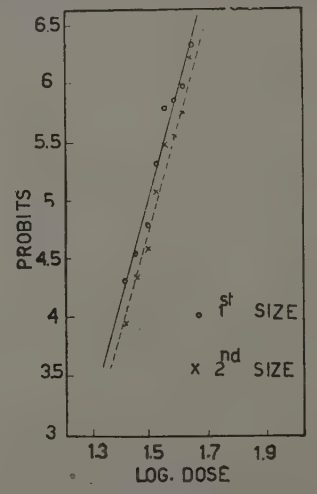
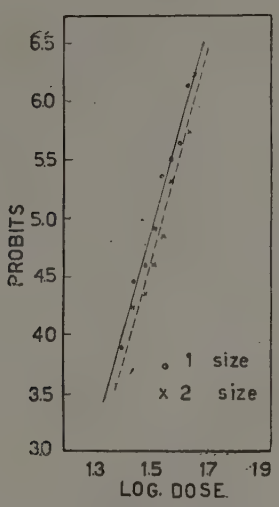


Fig. 11 (left): Dose kill regression lines for the fourth larval instar of *Ephestia kuehniella* Zell.— Fig. 12 (right) : Dose kill regression lines for the fifth larval instar of *Ephestia kuehniella* Zell.



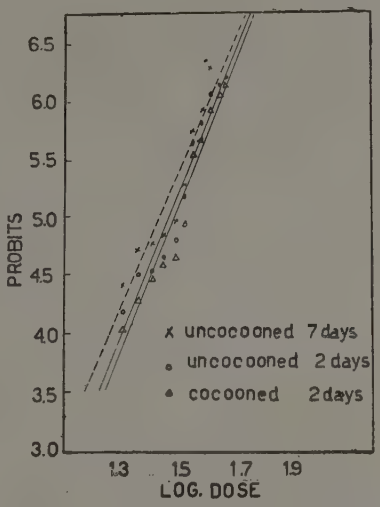


FIG. 13 (left) : Dose kill regression lines for the sixth larval instar of *Ephestia kuehniella* Zell. — FIG. 14 (right) : Dose kill regression lines for the pupal stage of *Ephestia kuehniella* Zell.

2. The LD_{50}s and the LD_{95}s

In the following paragraphs comparisons between the relative toxicity of the fumigant to the different larval instars studied will be based on the four hours median lethal concentrations (LD_{50}s) and the 4 hours LD_{95}s (see tables I and II).

Whilst this procedure of comparison is valid for the conditions of this work in which only one period of exposure was adopted, some comment should be made here on the fact that toxic effect is really some function of concentration and duration of exposure according to the well known Haber's equation, $c \times t = w$ (c = concentration of fumigant; t = period of exposure; w = constant level of mortality). On the assumption that this equation is followed, the relative susceptibility of the species for all durations of exposure will be obtained by comparing the regression lines for any one period of exposure. It is now known that under certain conditions, Haber's equation is not obeyed and consequently it is possible that the relative susceptibility may change in magnitude and perhaps in sign if comparisons are made at other periods of exposure. Conditions under which this equation does not correspond with experimental data have been found by different workers, e.g. FLURY (1921), BRINELY and BAKER (1927), and KNIGHT (1925) demonstrated that the relation $c \times t = w$ is valid only within certain limits of exposure time and of concentration, and NAHAL (1952) demonstrated a divergence from this equation due to changes in the forms of the concentration time curves.

Inspection of results in Tables I and II shows that in general the LD_{50}s and LD_{95}s for all the instars of both species increased as the development proceeded.

In the case of the larvae of *Corcyra cephalonica*, Stain. the LD_{50}s for the smaller size of the 1st. to the 6th. instars were 10.61, 12.29, 12.64, 14.89. 15.32 and 16.40 respectively. Those for the bigger size are 11.79, 13.61, 13.66, 16.12, 16.95 and 17.72, being higher than the corresponding LE_{50}s of the smaller sizes. The graphical representation of these results shown in Fig. 15B. indicates that the increase in resistance

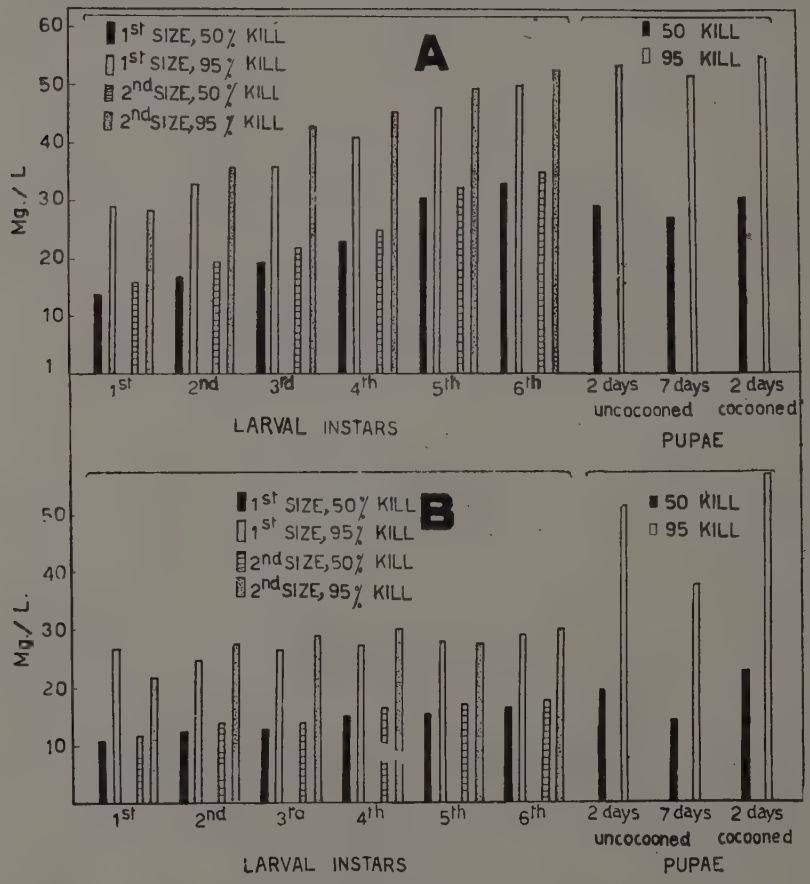


FIG. 15 : 50% and 95% kill doses for the different larval instars and pupal stages of (A) *Ephestia kuehniella* Zell., and (B) *Corcyra cephalonica* Stain.

with age proceeds nearly at a uniform rate. Nearly a straight line could be drawn passing through the tops of the columns in the histogram with some points up and down, which is a usual feature in such biological studies. In other words, it generally

seems that after each moult in most cases, the emerging larva is more resistant to the fumigant than it has been throughout the preceding instar. At the end of the larval life, the LD_{50}s is about 1.7 times its values just after hatching (see Table III for the relative resistance of all the instars). The relative resistance shown in this Table was calculated from the LD_{50}s by assigning an arbirary value of 1.00 as being the resistance of the first size of the first larval instar of *Corcyra cephalonica* Stain. Since these relative resistances have been obtained from the LD_{50}s, it should be realised that the trend of a relative resistance obtained from the LD_{95}s might not be the same as that found for the LD_{50}s.

Ephestia kuehniella Zell. behaved nearly in the same way as *Corcyra cephalonica* Stain., except that the increase in resistance of larvae with age did not proceed at a uniform rate; in the 5th. and 6th. instars, a marked increase in resistance being shown. The LD_{50}s of the smaller sizes of the 1st to the 1st instars are 13.95, 16.74, 21.65, 24.47, 32.32 and 34.91 respectively. Here, the larvae at the end of its life is

TABLE III

The L.D.$_{50}$*s and the relative resistance of the different larval instars and pupae of* Corcyra cephalonica *and* Ephestia kuehniella.

Instar		L.D.$_{50}$s of Corcyra cephalonica	Relative resistance	L.D.$_{50}$s of Ephestia kuehniella	Relative resistance	Difference between the LD_{50}s
Larvae						
First instar	First size	10.61	1.00	13.95	1.31	3.34
	Second size	11.79	1.12	15.89	1.50	4.10
Second instar	First size.....	12.29	1.16	16.74	1.58	4.45
	Second size.....	13.61	1.28	19.29	1.82	5.68
Third instar	First size	12.64	1.19	19.09	1.81	6.45
	Second size.....	13.66	1.29	21.65	2 04	7.99
Fourth instar	Frist size	14.89	1.40	22.80	2.16	7.91
	Second size.....	16.12	1.52	24.47	2.30	8.35
Fifth instar	First size	15.32	1.44	30.20	2.85	14.88
	Second size.....	16.95	1.60	32.32	3.05	15.37
Sixth instar	First size	16.40	1.55	32.74	3.08	16.34
	Second size	17.72	1.67	34.91	3.29	17.19
Pupae						
Uncocooned	2 days old	19.22	1.81	29.04	2.74	9.82
Uncocooned,	7 days old	14.32	1.35	26.85	2.53	12.53
Coconned,	2 days old	22.45	2.11	30.16	2.84	7.71

about 2.5 times more resistant than it was at the beginning of its life (see Table III and Fig. 15A).

By comparing LD_{50}s of the larval instars of both species (Table III), two points could be deducted. Firstly, the larvae, of *Ephestia kuehniella* Zell. are more resistant to the effect of the used fumigant than the larvae of *Corcyra cephalonica* Stain. Secondly, this difference in resistance becomes more distinct as the instars proceed especially in the last two instars which are the most resistant.

B. The pupae

The log. concentration-probit kill regression lines of the pupae of the two species are shown in Figures 7 and 14. As mentioned before the pupae were tested in cocoons when they were 2 days old and without cocoons when 2 and 7 days old.

The slopes of the regression lines of the pupae of the two species are considerably less than the slopes of the last larval instar, indicating the distinct difference in the resistance of the larvae and pupae to the effect of the fumigant. By comparing between the LD_{50}s of the uncocooned pupae at 2 and 7 days old, it is noticed that the old pupae are less resistant to the effect of the fumigant than the young ones in the two species. Such phenomenon is the reverse to that obtained in the case of the larvae, where the older larvae proved to be more resistant than the younger ones.

By comparing the LD_{50}s of the 2 days old pupae and the larger size of the last larval instar, it is seen that the pupae of *Corcyra*, especially those with cocoons, are more resistant than the last instar larvae, whereas in the case of *Ephestia* pupae, both cocooned and uncocooned, are less resistant than the last instar larvae (see Tables I, II and III). But when comparisons are based on the LD_{95}s, the 2 days old *Ephestia* pupae, especially those with cocoons, appear slightly more resistant than the larger size of the last instar larvae, whereas the difference is very considerable in the case of *Corcyra*. The LD_{95}s of the larger size of the last instar larvae and the 2 days old pupae without cocoons of both *Corcyra cephalonica* Stain. and *Ephestia kuehniella* Zell. are 30.09 and 51.04 and 52.38 and 53.18 mg/l. for the two species respectively. As for the 7 days old pupae of *Corcyra* the LD_{95} is considerably higher than the LD_{95} of the larger size of the last instar larvae, whereas in *Ephestia*, it is slightly less.

In both species, as to be expected, the pupae with cocoons are more resistant to the effect of the fumigant than those without cocoons. Of course the cocoons hinder the difusion of the gas, but as the results indicate, such hinderence is not so great as it is generally thought. The LD_{50} for the 2 days cocooned pupae and uncocooned pupae of both *Corcyra* and *Ephestia* are 22.45 and 19.22 and 30.16 and 29.04 respectively.

IV. DISCUSSION

The study of literature dealing with the toxicity of insecticides shows that the susceptibility of insects to different insecticides, including fumigants, has often

been measured without any exact reference to the stage of development of the test insect. Apart from the fairly detailed work carried out recently by MUKERJEA (1953), the stages used in toxicological estimations are more frequently adults, full grown larvae or mymphs, less often eggs or pupae, without giving any indication to their ages. The results of MUKERJEA work showed clearly the need for obtaining informations on the fluctuations of resistance that occur during the development of any insect pest that is to be controlled by the use of insecticides. Such information appear necessary as it will help timing of application and also disclosing the presence of resistant stages that may bear on the efficiency of the chemical control. The aim of the present study, was to obtain information concerning the relative resistance of the different larval instars and pupae of *Corcyra cephalonica* stain. and *Ephestia kuehniella* Zell. against the effect of fumigation by carbon disulphide, similarly to the work done by MUKERJEA concerning contact insecticides.

Although the results mentioned here will apply only to the used fumigant and the insects under test, yet they will throw some light on the question of susceptibility of insects at their different developmental stages to the effect of fumigants in general. Further study on the effect of different fumigants on different insect species is required, before certain generalisations could be reached.

The effect of fumigation on each larval instar of both *Corcyra* and *Ephestia* was measured, and the relative resistance of the different instars was found. Also, the resistance of the pupae in two different ages during their development was tested and compared with that of the larvae. The larvae of different instars and of different ages within each instar were isolated by size. Two sizes in each larval instar were selected, one at the beginning of the instar and the other prior to its end. The pupae were tested when 2 and 7 days old. The different factors that might effect the results of fumigation were considered and all aspects of technique were described. As experimental design has been adopted to provide basis for comparison of relative resistance which was based on the shapes and slopes of regression lines showing the changes of mortality with changes in dosages, as well as the LD_{50}s and LDs_{95}.

The following main conclusions have been made of the relative resistance of the larval instars and pupae of the two species studied.

1. — *Corcyra cephalonica* Stain. during its larval and pupal stages is more susceptible to the effect of the fumigant than *Ephestia kuehniella* Zell. Such difference in resistance becomes more prominent in later instars.

2. — In both species the larvae, during the large part of their development, are more susceptible to the effect of the fumigant than the pupae.

3. — In both species, the resistance of the larvae increases from the 1st to the 6th. instars, in varying degrees in the two species and from one instar to the other in the same species.

4. — Change in resistance occurs also within any given larval instar; the larvae at the end of the instar becomes more resistant to the effect of the fumigant than at its beginning.

5. — The resistance of the pupae at the end of the pupal stage is less than at the beginning of pupation.

As regard the difference in susceptibility that has been observed between the two species studied, this phenomenon goes in line with the known fact that differences in susceptibility might occur even among related species of the same genus, as in the case of *Calandra granaria* and *Calandra oryzae*.

COTTON (1932) found that a 50% higher dosage of carbon disulphide is required to get a complete kill of *C. granaria* than dosage used for *Calandra oryzae*. *Calandra orysae* is much more active by nature than *Calandra granaria*, and probably has a higher rate of metabolism, and difference in resistance might be due to the difference in the rate of metabolism between the two species. The difference in susceptibility to fumigants between *C. oryzae* and *C. granaria* has also been demonstrated by other workers using other fumigants; e.g. BUSVINE (1938) working with ethylene oxide, SALMOND (1953) working with hydrogen cyanide, and NAHAL (1953) working with hydrogen cyanide, ethylene oxide and methyl bromide. *Corcyra cephalonica* might also have a higher rate of metabolism than *Ephestia kuehniella*, indicated by the fact that *Corcyra* has a shorter period of life-cycle than *Ephestia* (unpublished work by the authors).

As regards the difference in susceptibility between the larvae and pupae in the two species studied, this also might be due to the difference in the rate of metabolism during different stages of the insect development. The adult has the highest rate, then the larva, then the pupa. Accordingly, a corresponding difference in susceptibility is expected. COTTON (1932) carried out tests with adults, larvae and pupae of *Tribolium confusum* Duv. and *Ephestia kuehniella* Zell. and found out that such explanation is true. Also the results of the present work support this view. In both species, the recently transformed pupae were found to be more resistant than the larvae, especially when comparisons were made on the base of the LD_{95}s.

Resistance of the larvae to the effect of fumigation increases gradualy by age from the 1st to the 6th. instar in both species. The increase in resistance continues through the period of the same instar. These findings are in accord with the findings of other workers such as CAMPBELL (1926), DU CHANOIS (1947), YOSIDA (1948), and MUKERJEA (1953) who examined the effect of different insecticides, other than fumigants, on the larvae of different instars of some insect species. MUKERJEA, studied the rate of respiration of *Diataraxia oleracea* and *Tenebrio molitor* at different ages and observed that while the age of the larvae increased, the rate of respiration fell and that the highest metabolism was reached in the 1st. instar larva of *D. oleracea* and in the smallest sized larva of *T. molitor*. He explained the increase of resistance of these larvae to D.D.T. during their developmental stages to the difference in their respiratory metabolism. If this might apply to a contact insecticide such as DDT, it might as well apply to fumigants which reach the tissues of insects mainly through the spiracles with the process of respiration.

There is another explanation for this variation in resistance between the

different larval instars. It is known that the insect cuticle increases in thickness as the insect grows. This increase in thickness may interfere with the entrance of the poisons into the insect body through the body wall. A correlation has been found between the thickness of the body wall and the entrance of other insecticides such as pyrithrins as indicated by the results of WIGGLESWORTH (1942), ROBINSON (1942), HURST (1943), and PEPPER and HASTINGS (1943). WAT (1950) has shown that the endocuticle of the larvae of successive instars of *D. oleracea* increased in thickness as the age progressed. If this change in the thickness of the cuticle helps to explain the change in resistance of the larvae of successive instars to contact insecticides which should penetrate the body wall to accomplish their effects, it might not be a satisfactory explanation in the case of insect fumigants. But still it must be remembered that some of the fumigant find their way to the inside tissues through the body wall.

Also some relation might exist between the increase in resistance of the larvae as the instars proceed and the full development of the respiratory system in the full grown larvae. It is known that some insects can protect themselves against the effect of the fumigants by just closing their spiracles. This is the explanation of the phenomenon known as the "protective stupefaction" which has been demonstrated by GRAY and KIRKPATRICK (1929) in the case of the scale insects, and LINDGREN (1938) in the case of *Calandra granaria*. It might be that the full grown larvae are able to close their spiracles more tightly and thus getting to be more resistant to the fumigant than the young ones in which the respiratory system is not well developed.

Passing to the differences in resistance observed in the pupal stage, the experimental evidence indicated that the pupae of both species when tested 2 days after pupation, were more resistant to the fumigant than when tested prior to the emergence of the adults. Investigation of the respiratory rate of the pupae of various insects tends to show that the oxygen consumption and carbon dioxide output is high at first, then falls then rises again. This has been found by various authors, KROGH (1914), TAYLOR (1947), TAYLOR and STEINBACH (1931), and WIGGLESWORTH (1934). It seems that this phenomenon about respiratory rate is closely related with metabolic rate and susceptibility. The decrease in resistance to fumigants at the end of the pupal stage reflects the increase in respiration rate at the end of this stage. The findings of LINDGREN and SINCLAIR (1945) support this view. These authors, studied the sorption of HCN by the pupae of house flies and found out that the amount of HCN recovered per gram of pupae varies with their age. The amount of HCN recovered from pupae 1-3 days old is less than the amount recovered from pupae 3 to 5 days old, and progressively a greater amount is recovered from pupae 5 to 8 days old, and that is the time adults are about to emerge. These findings indicate that at a certain period, the pupae of insects show greater resistance to the effect of the fumigant. GOUGH (1939) found that the recently formed pupae of *Tribolium confusum* and those that were just about to emerge were

much more susceptible to HCN than those in the middle period. This was not possible to be proved in the present work owing to the fact that resistance of pupae was examined only at the beginning and the end of the stage.

Finally, as also been concluded by MUKERJEA (1953) if all the data are considered, it appears that the increase in susceptibility to the effect of fumigants can often be correlated with increased metabolic rate, although it is doubtful, in some instances at least, if this is the primary cause. In order to obtain a proper understanding of the problem, the following factors have to be investigated : (*a*) physiological and morphological changes during development; (*b*) factors influencing spiracular and cuticular diffusion; and (*c*) chemical factors influencing the action of the gas on the tissues.

V. SUMMARY

A fairly detailed study of the relative susceptibility of the different larval instars and pupal stage of *Corcyra cephalonica* Stain. and *Ephestia kuehniella* Zell. to fumigation with carbon disulphide has been carried out. Also studies on the variation of susceptibility due to age within the larval instars as well as the pupal stage were achieved. Two points in the development of each larval instar and the pupal stage, one representing the start of the instar and the second representing its end, were selected, and the susceptibility was determined at those two points.

An experimental design has been adopted to provide basis for comparison of relative resistance which was based on the shapes and slopes of regression lines showing the changes of mortality with changes in dosages as well as the LD_{50}s and LD_{95}s.

The results of the work can be summarised in the following points :

1. — *Corcyra cephalonica* Stain. is more susceptible to the effect of carbon disulphide than *Ephestia kuehniella* Zell. during its larva land pupal stages. This change in resistance becomes more prominent as the instars proceed.

2. — In both species, the larvae during the greater part of their development are more susceptible to the fumigant than the pupae.

3. — In both species, the resistance of the larvae increases from the 1st to the 6th. instar with varying degress in the two species and from one instar to the other in the same species.

4. — Changes of resistance also occur within any given larval instar. The larvae is more resistant to the effect of the fumingant at the end of the instar than at its beginning.

5. — The resistance of the pupae at the end of the pupal stage is less than at the beginning of the pupal stage.

Lastly, these results have been discussed and compared with results of other workers in an endeavour to reach to definite reasons for these changes in resistance

with change of stage and age. The final conclusion is that the increase in susceptibility to fumigants can often be correlated with increased metabolic rate, although it is doubtful, in some instances at least, if this is the primary cause.

VI. ACKNOWLEDGMENT

This investigation forms a part of the program of work in Department of Plant Protection, at the Faculty of Agriculture, Cairo University. The authors are indebted to Prof. Dr. AHMED SALIM HASSAN, head of the Department, for his valuable advice and encouragement.

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FIELD TESTS WITH SOME NEW SYNTHETIC INSECTICIDES FOR THE CONTROL OF *THRIPS TABACI* ON COTTON SEEDLINGS

[*Thysanoptera* : *Thripidae*]

(with 3 Text-Figures and 3 Tables)

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CONTENTS

Introduction. — Material and procedure. — Results. — Discussion. — Summary. — Acknowledgment. — References.

INTRODUCTION

The damage caused by thrips infestation to cotton seedlings has been recognized in Egypt since only the last fifty years. In this connection WILLCOCKS (1937) cites that "This insect, although it is one of if not quite the commonest Thrips in Egypt, did not come to be looked on as a pest of the cotton crop in its early stages until 1910". The same author continues that, "although Thrips is present in most cotton crops every year it appears that it is only in some years, quite occasionally in fact, the insects are so numerous and the damage they do so severe and widespread that even the most unobservant are forced to notice them".

Cotton plants are infested by two species of thrips : the onion thrips, *Thrips tabaci* Lind., which attacks the cotton seedlings during April and May, and *Frankliniella dampfi* Priesner (1923), which has been found occasionally on cotton plants towards the end of summer. The onion thrips is the main species that causes the

damage to the cotton seedlings in Egypt, and the control of which was the aim of the present work. Other predacious species of thrips have been found roaming around the onion thrips on the cotton seedlings.

Yearly variations in the degree of infestation may be due to climatic conditions, cultural practices, type of soil, time of planting or other factors (GHABN, 1948).

During the last ten years, an enormous amount of work has been done to determine the toxic effect of organic synthetic insecticides on different pests, including *Thrips tabaci* Lind., on its different hosts. To the authors' knowledge the only serious work on the use of insecticides against onion thrips on cotton seedlings in Egypt is the work of GHABN (1950), who presented the results of field tests with different old and new insecticides, against this pest on cotton seedlings and onions.

Field tests herein reported were conducted at the farm of the Faculty of Agriculture at Giza, during the period between the end of March and the beginning of May, 1956. The main purpose for such tests was to compare between the control effects of some of the new synthetic insecticides, most of which were not used by Ghabn, against the onion thrips on cotton seedlings.

In the first place, the authors made their plan on the basis to compare the control effects of the tested insecticides against both *Thrips tabaci* Lind. and *Aphis gossypii* Glover, two pests that infest cotton seedlings either simultaneously or successively. Aphid population on cotton seedlings during the period of the test was very thin and, consequently, its response to the tested insecticides was ignored.

Material and procedure

Two and a half acres of land under cotton, which have received the usual cultural practices, were chosen for the application of the selected insecticides. The land was divided equally into ten plots (1 to 10) of 0.25 acre each. Plot no. 8 was left untreated and the other nine plots were sprayed, each with its respective insecticide, as follows :

1. — Folidol (E605) : an emulsible concentrate containing 46.7% diethyl paranitrophenyl thiophosphate, used at a dilution of 50 cc./100 litres of water.

2. — Gusathion : an emulsible concentrate containing 20% of 0,0-dimethyl-S-(4-OXO-3H-1,2,3, Benzotriazine-3-methyl)-phosphorodithioate, at a dilution of 200 cc./100 litres of water.

3. — Metasystox : an emulsible concentrate containing 50% of 0,0-dimethylthiophosphoric-OCB-S-ethyl)-ethyl-ester, used at a dilution of 100 cc./100 litres of water.

4. — Chlorthion : an emulsible concentrate containing 50% O-C_3-Chloro-4-nitrophenyl) 0,0-dimethyl-thiophosphate, used at a dilution of 100 cc./100 litres of water.

5. — Nicotine sulphate (40%) diluted in the proportion of 150 cc./100 litres of water that contained one pound of soft soap.

6. — Gammalin : an emulsible concentrate containing 20% of gamma isomer of BHC, used at a dilution of 50 cc./100 litres of water.

7. — Diptrex : an emulsible concentrate containing 50% 0,0-dimethyl-2, 2, 2,-trichloro-1-hydroxy-ethylphosphonate, used at a dilution of 100 cc./100 litres of water.

9. — Agrocide : a dispersable powder containing 6.5% gamma isomer of BHC, used at a dilution of 500 grams/100 litres of water.

10. — Dieldrix 15 : an emulsible oil solution containing 18.6% technical dieldrin, diluted in three proportions : 750 cc., 375 cc. and 500 cc./100 litres of water.

All the diluted preparations mentioned above were used at the rate of 150 litres per acre, i.e. each plot was sprayed with 35 to 40 litres of the diluted preparation. The calculated doses of active ingredients per acre are recorded in Table I.

A total of three applications was made in each of the treated plots (except in case of plot no. 10), during the period of the experiment (March 26 to May 2, 1956). The first application took place at the appearance of the dicotyledonous leaves, the second application was two weeks later and the thrid application was three weeks after the second application.

Spraying of the insecticides was achieved by the use of knapsack compressed air sprayers equipped with hollow cone nozzles, and care was taken to spray both surfaces of the leaves. Counts of adult and nymphal thrips were made on 20 plants that were pulled at random from each plot and kept in tightly closed paper bags until examined very shortly in the laboratory. The tops of the plants were struck gently and repeatedly against a black sheet of paper until no more insects were left on the examined plants. The dislodged thrips were picked off with a moistened camel hair brush and counts were recorded. These counts were made at occasional intervals before and after each application of the insecticides.

Results

The number of thrips found on 20 cotton seedlings in different plots and at different times of infestation was arranged in Tables I-III, concerning results of the three insecticidal applications. Percentage reduction in thrips population was deduced by comparing counts of insects on treated plants with their respective counts on untreated plants of plot No. 8.

Figure 1 is a graphical representation of thrips counts in the check plot no. 8. It shows the degree of thrips infestation during the period of the experiment, indicating two peaks of nymphal thrips population. The first peak was reached around the 29th of March and the second peak around the 23rd of April. At the extreme end of the graph there is a start of a third raise in the nymphal thrips population.

Adult thrips population, as can be seen in Figure 1, did not follow the same pattern as that of the nymphs due to their active movements. Consequently, the nymphal thrips population only was taken into consideration when timing the insecticidal applications. The first application took place at the beginning of the first

thrips generation on cotton seedlings (26 of March), the second application at the end of the same generation (12th of April) and the third application at the end of the second generation.

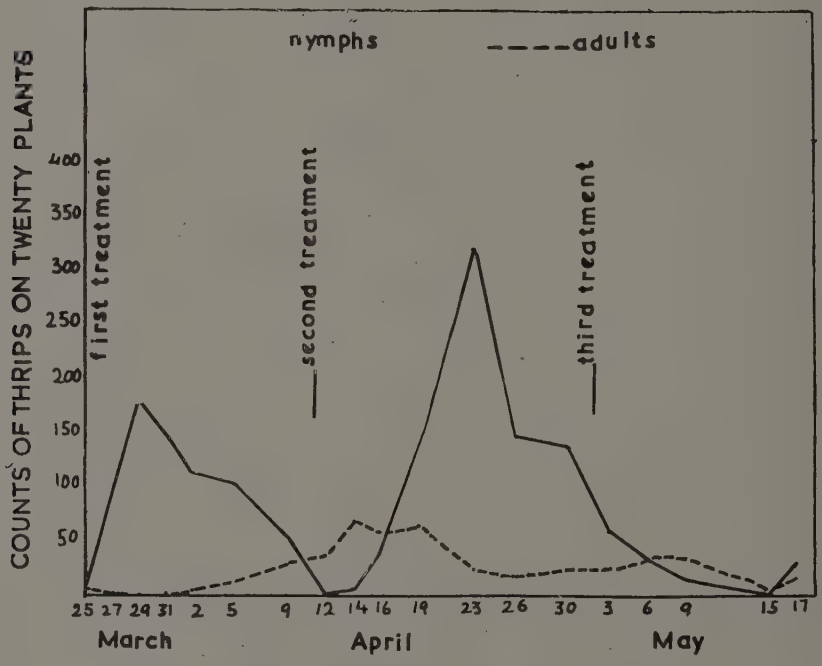

FIG. 1 : Thrips population in check plot during experiment.

In order to facilitate comparison between the control effects of the tested insecticides, the percentage reduction in the nymqhal thrips populations was plotted graphically in Figures 2 and 3. Percentage reduction after the third application was not considered because thrips population in all plots, including the check plot no. 8, dwindled rapidly, and results based on low counts may be misleading.

After consulting Tables I-III and Figures 1-3, the following results can be presented :

1. — Dieldrix 15 proved to be the most effective material among all the insecticides tested in this experiment in controlling the onion thrips, *Thrips tabaci* Lind., on cotton seedlings. Also Dieldrix 15 has the longest residual effect. Such a result could not be considered as definite until supported by further experiments, especially because shortage of this matdrial hindered reaching such confirmatıno. When the time of applying the selected insecticides approached, the authors had on

TABLE I

Counts and percentage reductions of onion thrips nymphs on cotton seedlings after application of insecticitdes in the field
(After first treatment, March 26, 1956)

Plot No.	Treatment	Concentration	Active ingredient per acre	Counts on 20 treated plants — % reduction compared with check plot									
				One day		Three days		Five days		Seven days		Ten days	
				% Count	% Reduc.	% Count	% Reduc.	% Count	% Reduc.	% Count	% Reduc.	% Count	% Reduc.
1	Folidol	50 cc./100 L.	35 gr.	—	100	—	100	3	98	15	87	18	83
2	Gusathion	200 cc./100 L.	60 gr.	—	100	3	98	4	97	11	90	42	61
3	Metasystox	100 cc./100 L.	75 gr.	—	100	2	99	9	94	17	85	34	68
4	Chlorthion	100 cc./100 L.	75 gr.	—	100	13	93	11	92	39	66	52	50
5	Nicotine Sulph.	150 cc./100 L.	90 gr.	24	69	159	12	148	—	90	21	82	23
6	Gammaline	50 cc./100 L.	15 gr.	—	100	26	26	33	77	58	49	52	50
7	Diptrex	100 cc./100 L.	75 gr.	—	100	23	87	43	70	78	31	130	—
8	Check plot	—	—	78	—	180	—	145	—	114	—	106	—
9	Agroside	500 gr./100 L.	49 gr.	—	100	2	99	29	80	48	58	64	40
10	Dieldrix 15	750 cc./100 L.	210 gr.	—	100	—	100	—	100	—	100	—	100
11	Left untreated ..	—	—	—	—	—	—	—	—	—	—	—	—

TABLE II

Counts and percentage reductions of onion thrips nymphs on cotton seedlings after application of insecticides in the field
(After second treatment)

Plot No.	Treatment	Concentration	Active ingredient per acre	Counts on 20 treated plants — % reduction compared with check plot									
				One day		Three days		Five days		Eight days		Twelve days	
				% Count	% Reduc.	% Count	% Reduc.	% Count	% Reduc.	% Count	% Reduc.	% Count	% Reduc.
1	Folidol	50 cc./100 L.	35 gr.	—	—	—	100	—	100	14	91	26	92
2	Gusathion	200 cc./100 L.	60 gr.	—	—	—	100	—	100	15	91	12	96
3	Metasystox	100 cc./100 L.	75 gr.	—	—	—	100	—	100	4	97	16	95
4	Chlorthion	100 cc./100 L.	75 gr.	—	—	—	100	—	100	4	97	14	96
5	Nicotine Sulph.	150 cc./100 L.	90 gr.	—	—	2	50	34	15	140	7	—	—
6	Gammalin	50 cc./100 L.	15 gr.	—	—	1	75	12	70	56	63	206	36
7	Diptrex	100 cc./100 L.	75 gr.	—	—	1	75	14	65	92	39	212	35
8	Check	—	—	—	—	4	—	40	—	150	—	324	—
9	Agroside	500 gr./100 L.	49 gr.	—	—	?	?	10	75	75	50	272	16
10	Untreated.....	—	—	—	—	—	100	1	97	2	98	40	88
11	Dieldrix 15	375 cc./100 L.	105 gr.	—	—	—	100	—	100	—	100	36	89

TABLE III

Counts and percentage reductions of onion thrips nymphs on cotton seedlings after application of insecticides in the field
(After third treatment)

Plot No.	Treatment	Concentration	Active ingredient per acre	Counts on 20 treated plants — % reduction compared with check plot									
				One day		Five days		Eight days		Twelve days		Sixteen days	
				% Count	% Reduc.	% Count	% Reduc.	% Count	% Reduc.	% Count	% Reduc.	% Count	% Reduc.
1	Folidol	50 cc./100 L.	35 gr.	—	100	—	100	6	57	8	—	8	78
	Gusathion	200 cc./100 L.	60 gr.	—	100	—	100	—	100	2	75	18	50
3	Matasystox.....	100 cc./100 L.	75 gr.	—	100	—	100	2	85	8	—	24	33
4	Chlorthion	100 cc./100 L.	75 gr.	—	100	—	100	—	100	2	75	12	66
5	Nicotine Sulph.	150 cc./100 L.	90 gr.	18	71	16	55	14	—	10	—	18	50
6	Gammalin	50 cc./100 L.	15 gr.	8	87	6	78	8	43	10	—	4	89
7	Diptrex	100 cc./100 L.	75 gr.	—	100	—	100	—	100	6	25	8	78
8	Check	—	—	62	—	36	—	14	—	8	—	36	—
9	Agroside	500 gr./100 L.	49 gr.	22	65	16	55	6	57	6	25	22	39
10	Dieldrix 15	500 cc./100 L.	140 gr.	—	100	—	100	—	100	—	100	—	100
11	Untreated	—	—	16	74	12	67	6	57	10	—	28	22

hand only a limited amount of Dieldrix 15 that would not suffice to spray the whole plot area (1/4 acre) for three treatments at the dosage recommended by its producer (210 grams of the technical dieldrin per acre). Thus, the original plot no. 10, allotted for the treatment with Dieldrix 15, was subdivided into the smaller plots nos. 10 and 11, each consisting of 1/8 acre. Plot 10 was sprayed with Dieldrix 15 at the

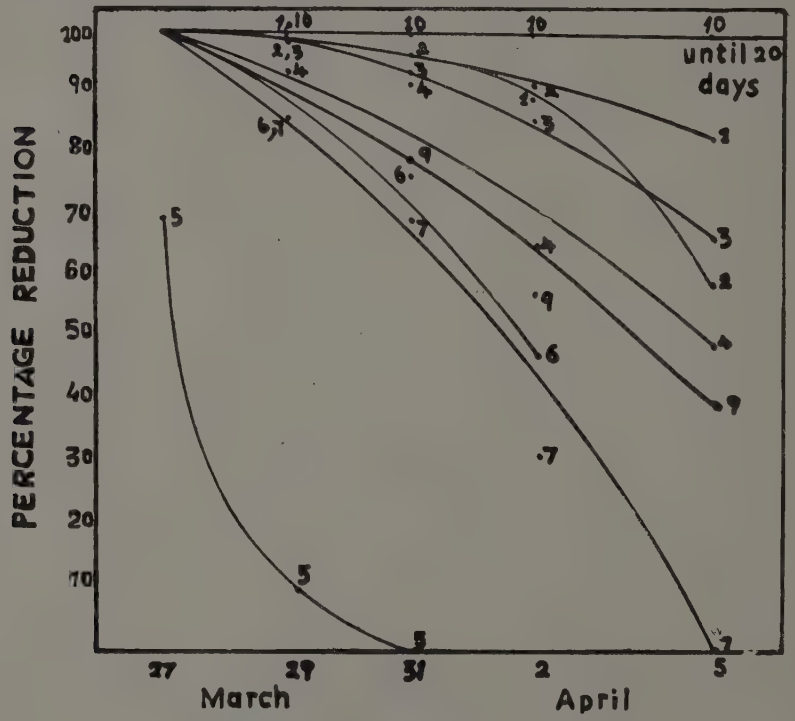

FIG. 2 : Percentage reduction after first treatment.

dosage of 210 grams of dieldrin per acre on the 26th of March (the date of the first application on other plots). The plants treated with Dieldrix 15 at such dosage remained free from thrips infestation for about twenty days, after which a very low nymphal thrips population started to appear on the treated seedlings and continued as such until May 2 (the date of the third application of other plots), when plot 10A was sprayed with Dieldrix 15 for the second time. In this treatment Dieldrix 15 was used at a lower dosage of 140 grams of dieldrin per acre, and the initial effect in this case was also very satisfactory. But this time it was not safe to determine the residual effect of Dieldrix 15. As previously mentioned, thrips population on untreated plants declined rapidly, shortly after the date of this treatment.

Plot 11 was sprayed on April 12 (the date of the second application of other plots), with Dieldrix 15 at the dosage of 105 grams of dieldrin per acre. This treatment caused the sprayed plants to remain free from thrips infestation for 10 days, after which the nymphal thrips began to appear in very low numbers and increased gradually. Therefore, Dieldrix 15 was used at three different dosages, and each dosage was used at a different time and on plants of different growth. Nevertheless, Dieldrix 15 used at the dosages of 210 and 105 grams of dieldrin per acre was, in both cases, more effective than the other insecticides tested. At the dosage of 210 grams per acre eradication of thrips on treated plants lasted for twenty days, while at the dosage of 105 grams the residual effect lasted only for ten days.

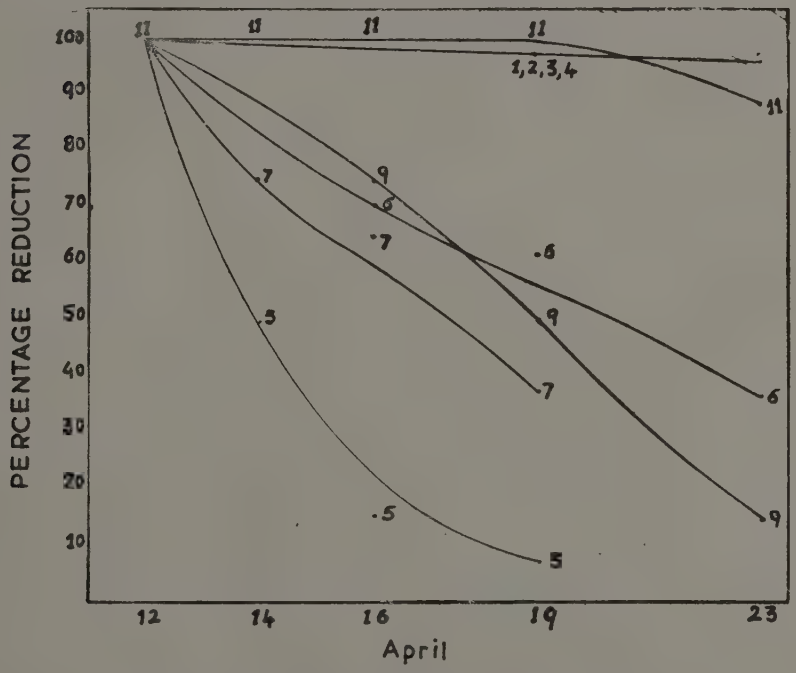

FIG. 3 : Percentage reduction after second treatment.

2. — The phosphorous compounds (Folidol, Gusathion, Chlorthion, Metasystox) used at the dosages of 35, 60, 75 and 75 grams of active ingredient per acre respectively are highly effective against the onion thrips infestation. They are the second in rank after Dieldrix 15 in that respect. The tested phosphorous compounds reacted differently, when used at the different times of applications. After the first treatment, which took place on March 26, the treated seedlings kept clean from

thrips infestation for three days. Then a very slight infestation began to appear and increased very slowly until the time of the next treatment. After the second treatment, that took place on April 12, the treated plants kept clean, or nearly so, for about twelve days.

3. — The control effect of nicotine sulphate on the onion thrips was, to a great extent, less satisfactory both in the initial and residual effects as compared with the other insecticides tested. Counts made on treated plants with nicotine sulphate showed a decided build up of nymphal thrips population nearly in the same manner as that followed on untreated plants.

4. — Gammalin and Agrocide at the dosages used gave an initial effect of 100% reduction in nymphal thrips population that lasted only for one day. Their residual effect was inferior to that of Dieldrix 15 and the first four phosphorous compounds.

5. — Diptrex which is the fifth phosphorous compound, used at the dosage of 75 grams of active ingredient per acre, gave the least insecticidal effect among the tested insecticides, except for the nicotine sulphate.

Discussion

All the nine insecticides tested in this experiment gave a full initial control of onion thrips, *Thrips tabaci* Lind., In cotton seedlings. The initial control is indicated by counts of nymphal thrips on 20 treated plants, picked out at random, 24 hours after the insecticide application. Substantial build up of thrips population did not take place after the initial control, except in the case of nicotine sulphate.

Dieldrix 15 gave the best control effect from the standpoint of the residual effect, especially when used at the dosage of 210 grams of dieldrin per acre. When lower dosages were used (105 and 140 grams per acre), the control effect did not vary considerably. The long residual effect of Dieldrin, as compared wit that of Lindane, Perathion, Aldrin and Toxaphene has been demonstrated by DECKER et al. (1950). HERMAN et al. (1950), working on the control of onion thrips with low volume spray, have shown that Dieldrin at 0.5 lb. per acre was more effective, both in its initial and residual effects, than the gamma isomer of BHC at 0.25 lb. per acre. RICHARDSON et al. (1952) used the high volume spray and found that Dieldrin at 0.25 lb. per acre was more effective than Parathion at 0.1 lb. per acre against the onion thrips. CAINES et al (1951) also indicated that Dieldrin at 0.09 lb. per acre was more effective than Toxaphene at 0.73 lb. per acre, and that Dieldrin showed more residual toxidity than either Aldrin or Toxaphene. According to the results of SLOAN et al. (1951), the effect of Dieldrin at 2 lb. per acre was superior against onion thrips to Lindane at 0.5 lb. per acre, two days after application. Nine days after application, Dieldrin still maintained thrips population reduction of 90% or more on treated plants, as compared with thrips population on untreated plants. The latter workers experimented also on Dieldrin at 0.5, 1 and 2 lbs. per acre, and found out that all the three dilutions gave highly significant reduction in the onion thrips population.

At the end of April infestation of spider mites was observed on the plants of all the plots of the experiment, including the untreated plants. The spider mites infestation was rather more severe on plants of plots no. 10A and 10B that were treated with Dieldrix 15. Owing to the fact that counts of spider mites on treated plants did not fall within the scope of the present work, such increase of spider mites infestation on Dieldrix 15 treated plants could not be determined. Reasons may be due to the long interval that elapsed between times of application in the particular case of Dieldrix 15, as previously described.

Among the phosphorous insecticides tested Folidol (E605) seems to give the best results and the longest residual effect. It is known that Folidol residue on treated plants lasts for about 3 to 5 days under the best conditions, although in many cases it fades away after 24 hours. The relatively long residual effect shown by this insecticide against the onion thrips may be attributed to its penetrative capacity into the green parts of plants, particularly into the leaves. Eggs of onion thrips are laid inside the leaf tissue and the hatched nymphs start to feed on the sap of the leaves. This causes a high initial effect and, consequently, a rather long residual effect. This explanation may also apply to the other phosphorous insecticides used in this experiment, excluding Diptrex.

According to IVY et AL (1955), Gusathion gave very promising results in the laboratory and in the field tests against most of the cotton pests. This worker found that in some cases, Gusathion gave better results than DDT, and that its residual toxicity was greater than that of Toxaphene.

Results obtained from the present experiment confirm those of IVY as indicated by the good effect of this insecticide in controlling thrips on cotton plants.

The other phosphorous insecticides can be arranged in a descending order of their effect as follows : Metasystox, Chlorthion and Diptrex successively. Diptrex at 75 grams of active ingredient per acre gave disappointing results, but its high initial effect is sufficiently promising to justify further testing at higher dosages.

Agroside as a dispersable powder containing 6.5% of BHC gave slightly better results than Gammalin as an emulsible concentrate containing 20% of BHC Such slight difference in effect may be related to the difference in the dosage of the gamma isomer per acre in the two cases of Agroside and Gammalin.

No phytotoxicity tests were made in this experiment, but there was no apparent difference in the growth of the treated and non-treated plants.

Summary

Field experiment was conducted to test the control effects of eight synthetic insecticides and nicotine sulphate against onion thrips infestation on cotton seedlings. All tested materials were sprayed by the knapsack compressed air sprayers at the rate of 150 litres of the diluted insecticide per acre. Concentrated materials were diluted in water at the proportions recommended by their producers. The control

effect was estimated by the population reduction in the counts of nymphal thrips on treated plants as compared with counts on untreated plants.

The results of the experiment are as follow :

1. — All the insecticides tested showed a high initial effect, but they do vary in their residual toxicity.

2. — Dieldrix 15, at dosages ranging from 105 to 210 grams of active ingredient (dieldrin) per acre, was the most effective and the most stable among the tested materials.

3. — The phosphorous compounds (Folidol (E605), Gusathion, Metasystox and Chlorthion) at the dosages of 35, 60, 75 and 75 grams of active ingredient per acre respectively, came second in order after Dieldrix 15. Folidol seems to be the most effective among the five phosphorous insecticides tested.

4. — Diptrex, the fifth phosphorous insecticide tested in this experiment, used at the rate of 75 grams of active ingredient per acre, proved more inferior than the other phosphorous compounds tested. Diptrex might prove more effective if used at higher dosages.

5. — Gammalin (L.C.) and Agrocide (W.P.), two gamma isomer of BHC compounds, afforded protection against the onion thrips, but over a shorter period than the phosphorous compounds tested.

6. — Nicotine sulphate (40%) at the rate of 90 grams of active ingredient per acre gave the poorest effect of all the insecticides tested against onion thrips infestation on cotton seedlings.

ACKNOWLEDGMENT

This investigation froms a part of a program started by the Plant Protection Department at the Faculty of Agriculture, Cairo University, in an attempt to find out the most successful means of controlling the cotton pests in this country.

The authors are indebted to Prof. Ahmed Salem Hassan, Head of the Department, for his interest and encouragement.

Thanks are due to the firms of Shell Chemicals, Imperial Chemical Industry and Sabet Brothers, for supplying the insecticides used in this work.

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EXTERNAL MORPHOLOGY AND BIOLOGY OF THE BEAN POD-BORER, *ETIELLA ZINCKENELLA* TREIT.

[*Lepidoptera* : *Pyralidae*]

(with 15 Text-Figures and 9 Tables)

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CONTENTS

I. Introduction. — II. Synonymy and distribution. — III. Character and extent of damage.— IV. Host plants. — V. External morphology. — VI. Biological processes. — VII. Annual cycle and fluctuation. — VIII. Parasites. — IX. Summary. — X. Acknowledgment. — XI. References.

I. INTRODUCTION

Beans are leguminous human-food crops which may be placed in various Egyptian rotations. They are excellent food stuff in the form of green or dry beans and their seeds are rich in proteins. The main sources of beans are believed to be South-western Asia and South America. Several varieties of beans are cultivated in the districts of Giza, Kom-ombo, El-Minia and in different localities around the big cities. The most common cultivated varieties of beans in Egypt are the kidney beans (*Phaseolus vulgaris*), cowpea (*Vigna sinensis*), lima beans (*Phaseolus limensis* and *P. lunatus*). Commercial lima beans are of two sizes; the smaller sieva beans (*Phaseolus lunatus*), and the large lima beans (*Phaseolus limensis*). Lima beans have been recently introduced into Egypt, but their cultivation was greatly checked owing to the severe attack of the pod-borer, *E. zinckenella*. At present, their cultivation is limited to certain areas in Upper Egypt where such attack is unfavorable to the insect pest.

Kidney beans is principally cultivated in two plantings: Sefi, during January to April, and Nili during July to September. The crop is marketed as dry or fresh shelled seeds, and also as green pods, and is available in Cairo from different localities at all times of the year.

Cowpeas are used as dry seeds or green-pods and are cultivated, as in case of the kidney beans, in Sefi and Nili plantings, mainly at Giza district and Upper Egypt.

Lima beans and cowpeas suffer from the heavy attack of the Pyralid pod-borer, *Etiella zinckenella*, which feeds on the seeds inside the green pods. Kidney beans are not touched by the pest. The bean Agromizid fly, *Agromiza phaseoli*, attacks the three types of beans, mainly during the seedling stage and causes heavy losses. Also, the larvae of the blue tiny butterfly, *Cosmolyce baeticus*, infest the green pods of the three beans and could be mistaken for *Etiella zinckenella*. The two kinds of infestations could be distinguished by the fact that in case of *Cosmolyce*, the larvae invariably keep the exit holes open through which they force out the faeces and other material to accumulate conspicuously outside the holes. On the other hand, *E. zinckenella* larvae leave almost no outside evidence of their presence, until at a very late stage when the infested pods become flaccid and wrinkled.

Etiella zinckenella was described by Friedrich Treitschke (1832), and then long after, scattered brief notes and reports were made by different workers. Larson (1926) and Scott (1940) referred to the economic importance and character of damage of this pest. Chittenden (1909) and Wolcott (1933) gave a general description of the different stages and the pest distribution all over the world. A list of about 20 host plants was given by Flanders (1930), and Leonard and Mills (1931); it indicates that the pest infests numerous wild and cultivated legumes. Hyslop (1912) mentioned a few morphological points, concerning the head and the pronotal shield of the larva, and Forbes in 1923 gave a setal map of the prothorax and mesothorax of the fully grown larva.

Hardly any serious study has been made on *Etiella zinckenella* in Egypt. Thus, this paper was intended to make a thorough investigation on the extent of damage of the pest, morphological descriptions of all pest stages and biological studies under laboratory and field conditions.

In spite of the fact that the bean pod-borer causes great damage to the yield of the lima beans and cowpeas, yet the majority of bean cultivators in Egypt are not acquainted with it. Eventually they feel the unprofitable yield they get and come to stop cultivating such beans on their land.

II. SYNONYMY AND DISTRIBUTION

In his original description Treitschke (1832) has placed *Etiella zinkenella* under the genus *Physis*. Zeller (1881) who examined specimens of the species

brought from Sierra Leone, West Africa, Madagascar, Colombia, South America and Carolina, called it *Etiella schisticolor*. HULST (1890) redescribed it under the specific name *villosa*, and considered Colorado, California, Florida, South America, Europe and Central Asia as its natural habitat. DAYER (1909), in his Catalogue, gave Arizona as an addition to the habitat. *Etiella zinckenella* has been also described under at least thirteen names, including *Etiella rubribasella* Hulst.

It has also been recorded in literature from France by MILLIERE (1861), Hungary by KADOCSA (1924), Russia by KOLESNIKOV (1916), Egypt by FORBES (1921), the Dutch Indies by VAN HALL and MEDED (1926), and Ceylon by HENRY (1924). HYSLOP stated in 1912, that the U.S. National Museum collection contained specimens of typical *zinckenella* from New Hampshire, Rhode Island, Florida, Texas, Oklahoma and Colorado.

During the years 1952 and 1953, the writers observed that this pyralid is widely distributed and fairly abundant in the Giza area on lima beans and cowpeas in the field of the Faculty of Agriculture. Specimens have also been collected by the authors from other localities around Cairo, where susceptible crops are cultivated, as Kanater, Bahtim, Mansouria and Dokki.

During 1954, the authors paid visits and received samples from different localities in order to gather some data concerning the distribution of the pest in Egypt. Larvae of *E. zinckenella* were found in Embaba, Giza, and Dokki (at Giza province). It was also found during July of this year at Bahtim, Kayloub, and Mataria (at Kalyoubia province). In June and July 1954 samples of cowpea pods were examined from Quesna, Menouf (at Menoufia province), and were found to be infested. Cowpeas pods from Sherbeen, Mansoura, Talkha, were also found to be infested. At Minia el-Kamh (Sharkia province), and even at the new Tahreer province, the cowpeas pods suffered from this pest. Specimens of cowpeas pods cultivated at El-Minia and Beni-Suef in lower Egypt were examined and suffering pods were easily detected.

Specimens of this pest are found in the collection of the Ministry of Agriculture (Dokki, Egypt) indicating that it was found at Giza, during 1920, 1923, 1924 and 1929, on the green pods of pigeon peas, cowpeas and lablab. Other catches of the same collection were found at Dokki in 1925 on lablab, at Helwan in 1916 and 1924 on light, and at Dakhla oasis and Sina in 1943.

III. CHARACTER AND EXTENT OF DAMAGE

The larvae of *E. zinckenella* have the same habit of other pod-borers, that of entering the pods when they are very young, and thereafter feeding entirely within the pod, remaining there throughout their larval existence. The female moths deposit most of their eggs on or near the blossoms, blossom buds and growing pods, thus assuring the newly hatched larvae a source of food for several days. These young larvae feed first upon the blossoms, causing many of them to drop down, and later,

they attack the small pods. The initial losses caused by these caterpillars are especially obvious at the beginning of the crop, when the ground under the vines will be strewn with buds, flowers and young pods which have served as food for young catrepillars. When the pods become a little larger and firmer, they stand to the feeding of the caterpillars that burrow right inside them. As the caterpillar continues to feed inside, and the pod continues to grow, a callous is formed where the caterpillar burrowed in, effectively closing and entirely concealing the point of entrance leaving only a small dark spot (Fig. 1). This spot often remains visible even after the pod has

FIG. 1 : Sieva bean infested pod showing the spot of entry of the newly born larva. — FIG. 2 : Three infested pods of sieva bean showing damaged seeds.

ripened. To the unexperienced eye, the wormy pod looks quite healthy from the outside during the first stage of infection, as the inside caterpillar that is actively feeding and growing shows no external indication of its presence. The caterpillar may confine its activity to one bean, but often it chews into two or even three beans (Fig. 2). LARSON (1929), mentioned that the larva may devour only one large seed before it bores out of the pod to pupate. Usually it eats only one-fourth to one-half of the seed before going to the next. Frequently, every seed in the pod is ruined. By the time the larva approaches its full size, its accumulated excrement begins to rot and causes the pod wall to be mottled with black spots. Sometimes the infested pods become flaccid and wrinkled and often have a watery appearance and emit an unpleasant odour.

The extent of damage was determined in two crops of sieva beans and cowpeas. In September 1953, the authors examined 30,000 sieva bean pods, collected at random from about an acre under sieva beans at the farm of the Faculty of Agriculture, Giza. It was found that about 47% of these pods were infested, and that about 63.3% of the seeds of the infested pods were destroyed or have to be discarded. Thus the apparent loss amounted to 35.5% of the whole crop of seeds.

To determine the real damage caused to the dry seeds of sieva beans, one kilogram of seeds, taken from the harvested pods, were sorted, counted and weighed. The whole number amounted to 3377 seeds; 1745 were sound seeds and weighed

FIG. 3 : Sieva bean pod with a covered entrance hole — FIG. 4 : Sieva bean pod showing an exit hole.

665 grams, 1632 were infested seeds and weighed 335 grams. On the other hand, one kilogram of all sound seeds was found to contain only 2620 seeds. That is to say that if the whole 3377 of mixed seeds were all sound they should have weighed 1.288 kilogram. So, the loss comes to 288 grams in every kilogram of the actual yield. An addition of 335 grams, which is the weight of the damaged seeds, is also rejected, reaching with the whole loss to 623 grams in every kilogram of sound seeds, i.e., 62.3% loss.

When the infested sieva bean pods were examined to determine the nature of damage, they were divided into three groups : (1) the first group, amounting to 18%, was seriously damaged (most or all seeds were destroyed); (2) the second group, amounting to 54%, was moderately damaged (two seeds were affected), and (3) the third group, amounting to 28%, was slightly damaged (only one seed was affected).

The phenomenon of re-infestation is quite noticeable in the cases of sieva and lima bean pods, where each pod contains only from 2 to 3 seeds. In case more than one larva succeeded to enter a pod, consuming what they found of available seeds and not yet reaching their fully grown size, one of them would leave the first pod and make its way into another nearby healthy pod. In this case the secondary infested pod could be easily distinguished. It has two holes : the entrance hole of the migrating larva, and this is covered from the inside by a thin grayish membrane (Fig. 3), and an exist hole which is left open (Fig. 4). Out of 4770 infested sieva bean pods, 481 pods were found to be re-infested by grown larvae.

The other crop on which the extent of damage was determined, is cowpeas. One kilogram of dry seeds was taken from the yield, as in case of sieva bean, sorted, counted and weighed. The number of seeds in one kilogram amounted to 4842 seeds; 3790 were sound seeds and weighed 830 grams, 1052 were infested seeds and weighed 170 grams. On the other hand, one kilogram of sound cowpeas seeds was found to contain 3948 seeds, while of mixed seeds contained 4842. That is to say, that if the whole 4842 of mixed seeds were all sound, they should have weighed 1.225 kilogram. Then the loss comes to 225 grams in every kilogram. An addition of 170 grams, which is the weight of the damaged seeds, is also rejected. That makes a whole loss of 395 grams in every kilogram of sound seeds, i.e., 39.5% loss.

In 1954, the authors tried to make a comparable preliminary estimation of infestation in the green cowpeas (loubia) pods at different localities in lower Egypt, and the results are shown in Table I. Also degree of infestation in the green sieva

TABLE I

Degrees of infestation in green cowpea pods at different localities

Date of inspection	Number of pods examined	Number of infested pods	Percentage of infestation	Locality
June 19	200	52	26	Menouf
June 20	500	150	30	Tahreer Province
June 23	120	6	5	Embaba (Giza)
July 2	100	4	4	Embaba (Giza)
July 7	230	75	32.6	Menouf
July 8	150	8	5.3	Embaba (Giza)
July 13	170	5	3	Sherbeen
July 18	125	2	1.6	Bahtim
July 20	150	9	6	Embaba (Giza)
July 25	240	71	29.6	Menouf
August 3	154	—	—	Sherbeen
August 7	110	17	15.5	Embaba (Giza)
September 12	220	50	22.7	Giza
September 16	125	40	32	Giza
September 26	150	65	43.3	Giza
October 6	150	25	16.7	Giza
October 16	150	55	36.7	Giza

bean pods of late summer planting at Giza district was estimated, as shown in Table II.

TABLE II

Degree of infestation in green sieva bean pods at Giza

Date of inspection	Number of pods examined	Number of pods infested	Percentage of infestation
September 13	246	106	43
September 15	100	26	26
September 25	100	30	30
October 4	100	22	22
October 14	100	18	18

Degree of infestation in *Dolichos lablab* was found to be about 10% and in *Spartium junceum* (Retama) it was 70%. SHCHEGOLEV (1932) estimated the due loss of Soya beans in North Caucasus to be 6.2%, and WOLCOTT (1934) found it to reach 60 to 100% in the pods of *Crotalaria incana*.

IV. HOST PLANTS

Larvae of *Etiella zinckenella* have been recorded as feeding on the seeds of several species of leguminous plants. In California, KOEBELE (1885) found them to cause considerable damage to lima beans, and they were also found by MARSH (1908), infesting the same crop in that state. SCHWARZ (1887) observed them in the pods of *Crotalaria incana*, while BOGUE (1896) found the larvae in the seed pods of *Crotalaria sagittalis*. MARLATT (1896) found that the pods of Milk vetch (*Astragalus* sp.) were infested with this pest. Larvae were recorded by HERRICH-SCHAFFER (1909) as feeding on seeds of *Spartium junceum*. During 1910 and 1911, HYSLOP (1912) reared *Etiella* from the pods of common Lupines (*Lupinus* spp.). This pod borer has been recorded as infesting other varieties of legumes, of both wild and cultivated types : *Acacia* in Russia, Soya-beans in the Dutch East Indies, *Tephrosia candida* in Ceylon, green peas and *Robinia pseudacacia* in Hungary, *Colutea arborescens* in France, and *Lathyrus sativus* in Burma. In Porto Rico, it was found on Pigeon peas, cowpeas, lima beans and *Crotalaria*. VIKTOROV (1936) found that yellow and white ACACIA pods, near Saratov in Russia, had been severely infested with this pest. In Egypt, FORBES (1921) and WILLCOCKS (1922) found the larvae of *E. zinckenella* feeding on cowpeas, lima beans, bonavia beans (*Dolichos lablab*), and pigeon peas (*Canjanus indicus*). It was observed by SCOTT (1940) in string beans.

The authors were able to rear the bean pod-borer on the pods of *Spartium junceum* (Retama), lima beans, sieva beans, cowpeas, and *Dolichos lablab*. During 1953, other leguminous crops and shrubs were examined or tried in the laboratory, e.g. *Phaseolus vulgaris*, green peas, many varieties of *Acacia*, and *Crotalaria* sp., but they failed to serve as possible hosts. *Sesbania aegyptiaca* has not been found infested with the larvae of *E. zinckenella*, but was severely infested with the pod-borer *Cosmolyce baeticus*, specially during summer, as already recorded by ALFIERI (1916).

Owing to the fact that some authors have recorded lupinees, gren peas, and *Lathyrus sativus* as possible hosts for this pest, many fields in the provinces of Sharkia, Tahreer and Giza were checked, and in no case were found to be infested. Few infestations of *Cosmolyce* took place in the green pods of peas and lupines.

V. EXTERNAL MORPHOLOGY

The egg

The egg (Fig. 5) is oval, but rarely regular because its shape conforms with the space on which it is laid. Its measurements vary from 0.6 to 0.7 mm. in length

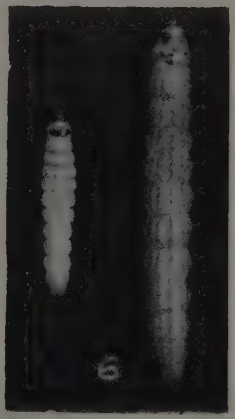

FIG. 5 : Eggs of *Etiella zimckenella* Treit. (highly magnified). — FIG. 6 : Fourth (left) and fifth (right) larval instars of *Etiella zinckenella* Treit. (× 3).

and from 0.3 to 0.45 mm. in width. The chorion is very delicate, the reticulation on its surface is often so irregular as to suggest no definite pattern. An empty egg shell shows the reticulation to consist of series of pyramides arranged in a manner very similar to that of pine-apple design.

The colour of the egg is glistening white when first laid, but after one or two days its upper surface becomes mottled with red spots. Most of the eggs noted in the field, were slightly pinkish or flesh-coloured. Immediately before hatching, the egg is more or less dark orange towards the center and the black head of the larva can be seen within.

The larva

Fully grown larva of *E. zinckenella* (Fig. 6) is 16 to 21 mm. long and 2.8 to 3.6 mm. wide. Its general colour is rosy, with a purplish tinge, much darker on the dorsal than on the ventral surface, which is somewhat faintly tinted. Fully grown larva may be pale green or cream coloured, but it converts to the purplish colour sometime before spinning its cocoon.

The head is more than half as wide as the first thoracic segment, honey-yellow in colour, with a black patch spreading over occellar area. Mandibles and tip of the labrum are black. There are six ocelli on each side of the head arranged in an anteriorly directed semi-circle at the base of the antennae.

The first thoracic segment is paler than the other two and bears a shield that is mottled with 3 pairs of brown dotted patches arranged as follows : lateral pair of bigger dots lying at each side of the pronotum, second pair of small markings lying medially and converging anteriorly to form a reversed V-shaped, third pair of small dots lying near the middle of the posterior edge. The thoracic shield carries four pairs of bristles.

The planta of the pro-leg is provided with a series of hooks or crochets, arranged on the first four pairs of prolegs in a bi-ordinal uniserial circle, but on the anal pro-legs, the crochets are limited to a semi-circle on the outer margin of the planta.

First instar : When first hatched, the larva is about 1 mm. long with a relatively black shiny head. The pronotal shield is rather indistinct, pale, shiny and very faintly shaded on the posterior margin. The body is yellowish, covered with very numerous large tubercles arranged in four longitudinal rows. From each tubercle there arises a single long bristle-like hair, dark in colour. The legs and pro-legs are pale and well developed.

Second instar : Body about 2 mm. long, yellowish white; head 0.35 mm. wide, shiny brown or dark, furnished with a few scattered hairs; pronotal shield same colour as head; tubercles small, hair shorter and less bristle-like than in the first instar.

Third instar : Body about 6.5 mm. long and 0.9 mm. wide; head shiny brown, 0.65 mm. wide; pronotal shield same colour as head.

Fourth instar : Body about 12 mm. long and 2.4 mm. wide, with four longitudinal rosy stripes along the dorsum; head about 1.05 mm. wide, dark brown; thoracic shield same colour as the head.

Fifth instar : Body about 15-18 mm. long and 2.8-3.2 mm. wide, pale greyish or cream in colour, with four dorsal purplish chestnut stripes; head 1.6 mm. wide, light yellow or light brown; pronotal shield provided with three pairs of dotty patches brown or black in colour.

The pupa

The obtect pupa measures from 8 to 11 mms. long and from 2.5 to 3 mms. wide. The newly formed pupa is bright green, changing in a few hours to a light brown. A few days before emergence the pupa is darkened by the colour of the adult within. The abdominal segments are quite visible in the pupa; the fifth, sixth, and seventh segments are movable, while the other segments are fixed. Each of the fourth, fifth and sixth abdominal segments bear a pair of short spines on the ventral surface. The terminal abdominal segment is armoured by an anal plate that is provided with 6 hooked bristles arranged at its distal edge (Fig. 7).

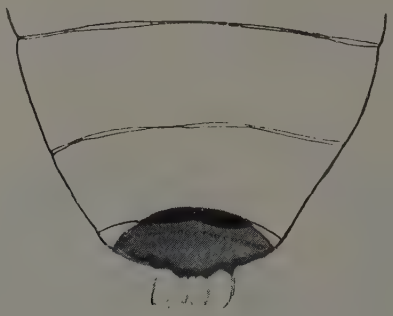

FIG. 7 : Distal end of pupa of *Etiella zinckenella* Treit. showing anal plate and bristles.

The moth

E. zinckenella is a small greyish pyralid moth (Fig. 8), wing expansion ranging from 24 to 27 mm. and body length from 15 to 18 mm. The labial palpi extend in front of the head in a peak-like manner. At rest, the two antennae settle on the middle line of the dorsum that they become undetectable. The moth stands in a pigeon-like manner raising its head and thorax and leaving its abdomen and distal end of wings to touch the ground. The folded grey wings are characterised by two white stripes that bound their sides and that are crossed by a broad yellowish region near their front end.

The head measures, in both sexes, 1.6 mm. (wide) by 1 mm. (long) in average. It is purplish brown in colour; labial palpi russet-grey above, grey below. Maxillary palpi are yellowish, brown on end, thickly scaled, and extending about twice the length of head.

The maxillary palps are composed of three segments; the first two segments in the male are larger than those of the female while the third segment in the female is longer than its equivalent in the male. The labial palps are quite evident

FIG. 8 : The female moth of *Etiella zinckenella* Treit.

and each is composed of three segments, which are longer in the male than in the female. The distal segment of the labial palp in the male is furnished with a conspicuous brush like tuft of hairs.

The pedicel of the antenna is much larger than the rest of segments in both sexes, but it is of a sinus form in case of the male. Also, the second flagellar segment of the male antenna is exceedingly long and curved, and is provided with long hairs that fringe its inner surface (Fig. 9).

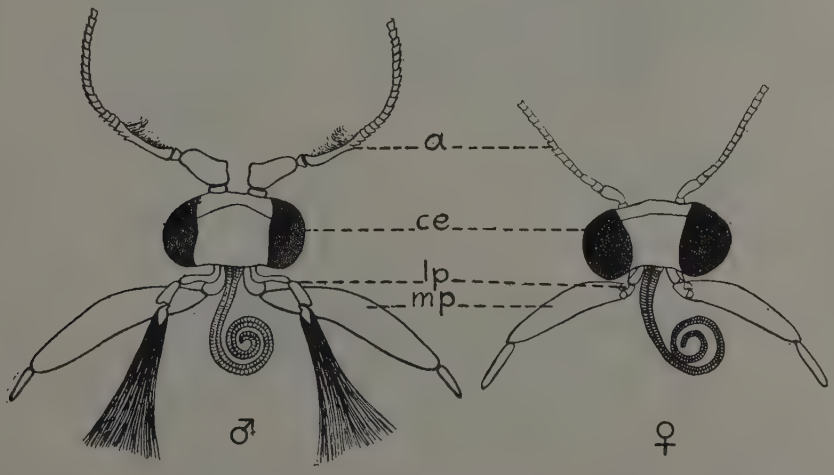

FIG. 9 : Head of *Etiella zinckenella* Treit., male and female (*a*, antenna; *ce*, compound eye; *lb*, labial palp; *mp*, maxillary palp.

At rest, the maxillary palps of the female diverge at their second joints, forming a V-shaped space between their tips, while those of the male moth run parallel leaving almost no space between them.

The prothorax is fuscous orange, the mesothorax and the metathorax are fuscous grey.

The fore-wings are long and narrow, mouse in colour with bluish gray tint. A broad white stripe extends from base along costa to apex. Extreme edge of costa is of ground colour broadening outwardly just beyond middle and fading away towards apex. At the basal fourth of the fore-wing there is a vertical dull yellowish stripe reaching from white costal stripe to the inner margin, edged inwardly with a row of maroon-brown scales; the scales being longer than usual. Hind-wings are semi-hyaline fuscous, deepening outwardly, with brown marginal line. In the female, the veins, apical area and the marginal line are brown.

The wing coupling apparatus is of the frenate type and, in both sexes, is composed of a single stout bristle that arises from a small swelling at the humeral angle of the hind wing, and passes beneath the fore wing where its apex is retained in position by locking mechanism or retinaculum, and in this manner the wings are held together. The retinaculum also exhibits no sexual differences as, in both sexes, it is very simple, being nothing more than a group of somewhat stiffened hairs or scales arising in the neighbourhood of Cu_1.

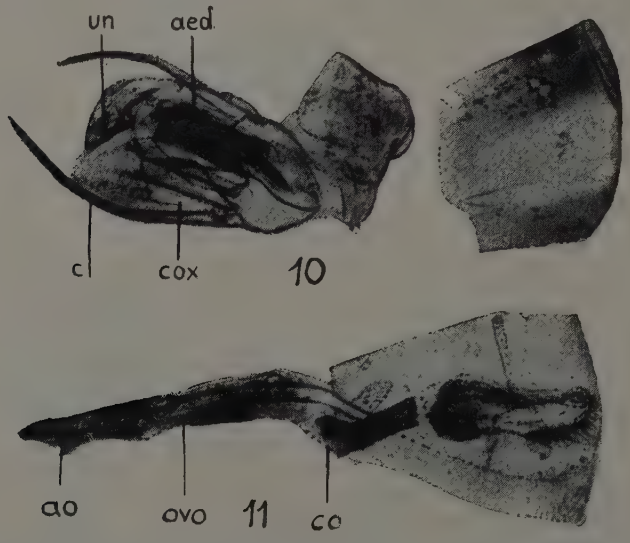

Fig. 10 : Male genitalia of *Etiella zinckenella* Triet. (*aed*, aedeagus; *cl*, clasper; *cox*, coxite; *un*, uncus. — Fig. 11 : Female genitalia (*ao*, anal opening; *co*, copulating opening; *ovo*, ovipositing opening).

The abdomen is composed of ten segments and all are thickly covered with grey scales, especially at the distal end of the male moth.

The male genitalia (Fig. 10) is composed of the ninth abdominal segment, the genital segment and its genital processes. The tergite of the genital segment is transformed into a narrow striped sclerite that hangs over the anal segment and is called the gnathos. The tenth tergite is transformed into the peak-like uncus. The coxites of the ninth sternite are fringed with long hairs and are provided with long hook-like claspers. The aedeagus is supported by the intersegmental membrane and the endophallus is studded with fine spikes beside a huge hook-like process.

The female genitalia (Fig. 11) is composed of the extended telescoped terminal abdominal segments, the eighth, ninth, and tenth segments that are tubular in shape and tapering towards the distal end. The copuating opening lies at the distal end of the eighth abdominal sternum, the oviposting opening lying at the distal end of the ninth abdominal sternum, and the anal opening lying beneath the paraprocts of the tenth abdominal segment.

VI. BIOLOGICAL PROCESSES

A. During the egg stage

Copulation : Under laboratory conditions (temperature about 25° C.) copulation takes place 24 to 30 hours after emergence. Eight recently emerged female

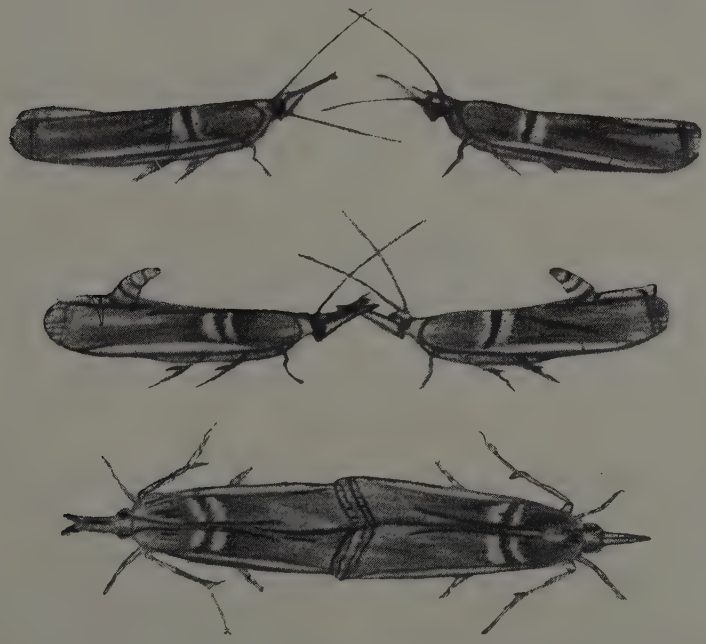

FIG. 12 : The steps of copulation process of *Etiella zinckenella* Treit.

moths were introduced to recently emerged male moths that were kept in separate vials; four pairs copulated after about 24 hours from emergence, two pairs after 28 hours, and the last two pairs after about 30 hours. The male moth first moves in a circle around the female, then gets to face her and seized her maxillary palpi. The terminalia of both moths are raised up to move in a semi-circular manner until the male genitalia get hold and firmly seize the female ovipositor. By this, the maxillary palpi are released and the two moths attain an end to end position, which they keep until the end of coitus that lasts from 25 to 60 minutes (Figs. 12). Then the female tries to withdraw its ovipositor from the grasp of the male genitalia by pushing it with its hind-legs.

The male moth is unable to mate with more than one female. Six newly emerged females were introduced to males that had once copulated, all moths were fed with sugar solution. Copulation was not achieved or even tried. Four of these females did not lay any eggs, the fifth laid 7 eggs and the sixth laid 13 eggs, but all these eggs failed to hatch.

Pre-oviposition period : Out of twenty fertilized and fed female moths, that were kept separately, thirteen began laying eggs on the second night after their emergence, five on the third night, and the last two females on the fifth night.

The pre-oviposition period of unfertilized female moths was also estimated to find out the effect of fertilization upon the process of oviposition or the number of eggs laid. Out of ten unfertilized females that were fed and separated, three started to deposit eggs on the third night after emergence, one on the fourth, four on the fifth and the last two on the sixth. All the eggs failed to hatch.

It is obvious that fertilization of the female moths stimulates oviposition so that pre-oviposition period becomes shorter and the number of eggs laid is greater than in case of unfertilized females (compare tables III and IV).

TABLE III

Eggs laid daily by ten fed and unfertilized females in August 1953

(Mean temperature 26.5°C.)

Days after emergence	Number of eggs laid by each female									
	1	2	3	4	5	6	7	8	9	10
First	—	—	—	—	—	—	—	—	—	—
Second	—	—	—	—	—	—	—	—	—	—
Third	2	7	1	—	—	—	—	—	—	—
Fourth	5	—	—	3	—	—	—	—	—	—
Fifth	—	—	—	3	10	—	—	—	1	11
Sixth	—	—	1	—	—	1	—	—	3	1
Seventh	died	died	5	—	—	died	13	1	—	—
Eighth	—	—	—	—	—	died	—	died	—	died
Ninth	—	—	died	died	—	—	—	—	died	—
Total	7	7	7	6	10	1	13	1	4	12

Oviposition : Female moths were observed closely while ovipositing on cowpeas (Loubia) in captivity. The abdomen was curved downwards and extended between the calyx and the pod itself (Fig. 13). Oviposition is initiated only when

FIG. 13 : Female *Etiella zinckenella* Treit. in the process of ovipositing between calyx and pod of lablab.

the proper leguminous pods are present. Twenty fertilized and fed females were left for several days in cages without introducing pods, and not a single egg was laid. When cowpeas pods were offered, plenty of eggs were deposited on the same day.

It was necessary to determine if the female moth has any preference for the same type of pods upon which its own larva was reared. Three groups of fed and fertilized female moths, ten moths each, were offered pods of a type other than the one that was used for breeding their larvae. The first ten female moths, previously bred on lima beans, were offered cowpeas pods and were able to deposit eggs that hatched. The second ten females, previously bred on cowpeas, were offered lima bean pods and again the females oviposited eggs that hatched successfully. The last ten females, previously bred on cowpeas, were given choice of cowpea pods and lima bean pods. Numerous eggs were laid on cowpea pods and not a single egg was laid on lima bean pods. This indicates that the female moth has a definite preference for the bean pods that were previously used by the larva but, in captivity, it can be induced to oviposit on other bean pods.

Oviposition site : In nature, the female moth may lay its eggs on any part of the host plant over the ground. Nevertheless, there are certain places that are preferred for oviposition. On cowpeas, the most preferred site is the place between the calyx and the pod (Fig. 14, right), followed by the terminal depression of the pod, then the whole surface of the pod. On lima beans and lablab the most favourable places are the calyx region (Fig. 14, left), the pod surface, around the base of the pod and leaf stalks. When the calyces and petals drop down upon drying, most of

the eggs become easily detected on the newly formed pods. Occasionally, eggs were found at the base of the pod petiole or in certain crevices on the pods. The writers came across some eggs, which were deposited inside the entrance of an exit hole of a larva on a lima bean pod.

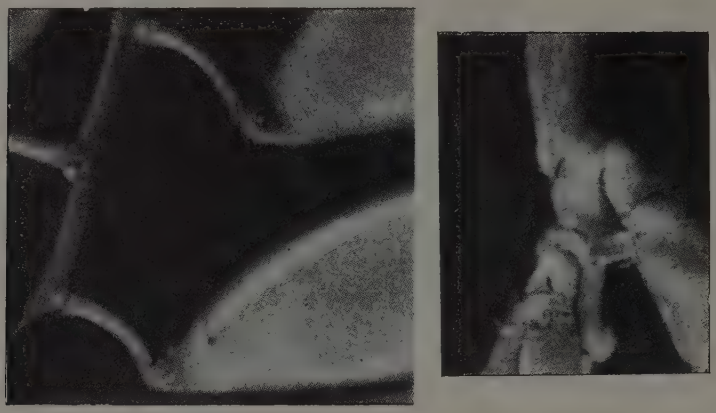

FIG. 14 : Oviposition sites on cowpeas pods (right) and on lima bean pods (left).

Different sites for oviposition were found by other workers. FLANDERS (1930) found some eggs deposited on the soil beneath a lima bean pod that was resting on the ground. WOLCOTT (1934) observed the eggs of *E. zinckenella* lying among the hairs on the pods of *Crotalaria incana*, usually in the keel-shaped depression on the upper surface of the pods, as many as 8 but often 3 to 4 eggs occuring on a single pod.

The eggs are deposited either singly or in a chain or in small patches. In captivity, the female moth may lay 2 to 12 eggs on a single pod and, at one time, the authors were able to detect as many as 30 eggs on a single pod of cowpeas.In nature, infested pods usually bear from one to six eggs, depending upon size of pod, time and degree of infestation. A pod that carries more than six eggs is hardly found.

Oviposition period and number of eggs laid per one female : In captivity, most of the fed and fertilized female moths keep ovipositing for a period of two to seven days. Out of twenty female moths, two continued to lay eggs for two days and then they died, five moths took three days to lay their eggs, three took four days, three took five days, four took six days and the last three moths spent seven days before they died. Most of the female moths continue to lay eggs until shortly before death. The number of eggs laid daily by a single female in captivity, varied considerably from 2 to 70 eggs.

Feeding of female moths affects their fecundity but, apparently, it does not interfere with their impulse to copulate or to oviposit. Ten pairs of unfed moths

copulated properly and the females laid fertilized eggs. The average number of eggs laid by fed females ranges between 47 and 178, while the number laid by unfed females ranges between 22 and 45 eggs.

FLANDERS (1930) mentioned that two female moths, that were captured from the field, each laid 250 eggs.

Incubation period and hatching : The incubation period of the fertilized eggs, at a mean temperature of 26.5 °C., lasted from 5 to 6 days (Table IV). According to FLANDERS (1930), the incubation period varies from 9 to 14 days, depending on the temperature. Eggs under this author's observation hatched in 10 days at a mean temperature of 67°F. (19.4 °C.).

Before hatching, the egg becomes more or less dark orange towards the centre. When ready to hatch, the young larva, which can easily be seen through the semitransparent chorion curled up head to tail, gnaws its way through the egg-shell and makes its escape. The egg-shell is left intact, except for the exit hole, as a small white object adhering to the pod.

B. During the larval stage

Larvae of *E. zinckenella* were first collected from the pods of the leguminous bush, *Spartium junceum*, at the end of June 1953. Later in July, cowpeas and sieva beans were found infested and more larvae were collected. The infested pods were kept in glass jars that contained wet sand. It was necessary to transfer the enclosed larvae to fresh pods every three days, until the fully grown larvae leave the pods to the underneath sand to spin their cocoon and pupate. Cocoons were collected and segregated in specimen tubes. Moths' sex was to be determined and each couple of moths was released in a cage (25 cm. × 25 cm. × 35 cm.). The proper leguminous pods were provided for the females to lay eggs on their surfaces and the sewere to be brushed off on a wet filter paper and kept in petri-dishes until they hatch. After hatching, the tiny larvae were ushered, by means of a delicate camel hair brush to proper leguminous pods through side slits that were sealed by means of melted wax. Each pod was to contain two larvae and the treated pods were laid in glass jars that contained some wet sand.

Number of instars : In order to determine the number of ecdyses, recently hatched larvae were transferred onto freshly-picked pods. Every pod was to contain a single larva and every two treated pods were laid in a petri-dish and the date of larval entry was recorded. The larvae inside the pods were examined twice daily, in search for the cast skin of the head. Thirty larvae were bred under such close observation, until they reached their fully grown size. Cowpeas pods were used as host plant for the first ten larvae, Sieva bean pods for the second ten larvae, and *Dolichos lablab* pods for the third ten of larvae. In spite of the utmost difficulty encountered through searching for the head capsule casts, especially of the first instar larvae, and to spot such casts among the larval faeces, yet at the end it was

TABLE IV

Fecundity and incubation period under 26.5°C. mean temperature

Days after emergence	Number of eggs laid by each of twenty fertilized females																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
First	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Second	52	—	—	—	4	10	17	—	8	18	25	5	7	—	5	3	—	—	7	14
Third	42	—	—	36	47	25	36	6	19	18	23	28	22	16	21	3	9	3	—	24
Fourth	40	—	—	20	died	20	12	—	10	12	died	50	22	12	21	16	13	12	20	13
Fifth	42	13	9	4		died	7	—	22	24		17	—	23	8	46	22	7	29	—
Sixth	2	4	28	died			died	34	24	20		11	8	—	12	12	7	25	11	—
Seventh	died	70	15					7	17	8		died	—	died	2	6		—	18	—
Eighth		—	6					died	5	died			2		—	7	died	—	died	died
Ninth		—	2						died				died		—	—		died		
Tenth		died	16												died	died				
Eleventh			died																	
Total	178	87	74	60	51	55	72	47	105	100	48	111	61	51	69	93	51	47	85	51
Inc. period in days .	5	6	6	6	6	6	6	6	5	5	5	5	5	6	6	6	6	5	5	5

possible to realize that *E. zinckenella* larvae moult four times before they reach their full size.

Measurements of instars : As a means of support for the above observations, it was thought to measure the head capsules of a good number of larvae at fixed intervals during their larval duration. Two hundred recently hatched larvae, were pushed into pin holes on the surface of sieva bean pods and were carried over to fresh pods every other day. Twenty of these larvae were taken daily, treated with 5% sodium hydroxide, stained with one percent water soluble erythrocine, dehydrated, and cleared in xylol. The head widths were measured under the microscope with the aid of a micro slide, and were found to run around five averages, representing five larval instars. These average measures are : 0.15 mm. for the first instar, 0.35 mm. for the second instar, 0.63 mm. for the third instar, 1.05 mm. for the fourth instar and, 1.6 mm. for the fifth instar, or the fully developed larva (Table V).

TABLE V

Measurements in millimetres of the five larval instars

Larval instars	Average body length	Average body diameter	Average head capsule width
First	1	0.2	0.15
Second	2	0.4	0.35
Third	6.3	0.9	0.63
Fourth.....	12	2.0	1.05
Fifth	15	2.7	1.60

Character of instars : The tiny just-hatched larva paces hurriedly in a to and fro movement on the pod surface, seemingly looking for a suitable place to get through. It keeps pacing actively for 15 to 30 minutes; out of twenty larvae laid on cowpeas pods, 10 larvae paced for about 15 minutes, 6 larvae for 20 minutes and 4 for 30 minutes. The time wasted by the hatching larvae, since they leave their egg shell until they burrow through the pod skin, is very critical from the stand point of chemical control. Had the tiny larvae been crawling on pod surfaces that had received a thin layer of an effective contact insecticide, they should have succumbed to the effect of the poison. When the hatched larva finishes its pacing job, it settles down to spin a protective funnel-like web at a spot, usually on the shaded side of the pod, chosen for burrowing through. Spinning the web keeps the tiny larva busy for a period of 20 to 30 minutes. When the web is finished, the larva starts to burrow its entrance hole to reach the seeds inside the pods. Again, the larva spends another 20 to 45 minutes to make its hole and to disappear completely inside the pod. Several hatching larvae may succeed to enter a single pod, and in one case there were seven

holes of entry on one pod. When such pods are searched for larvae, they usually contain two living ones and some fragments of others. This indicates that cannibalism does take place among the small larvae. The web funnels do not last long on the infested pods, but their skin reacts against the larvae burrowing their entrance holes, in the shape of very small dark spots which remain visible on the surface of the infested pod, even after it has ripened.

The first instar : Within the pod, the first instar caterpillar punctures through the hilum of the seed or the micropyle and devours the plumule, or may tunnel through one of the cotyledon. After feeding for a short time this larva becomes shiny milky-white in colour, with a dark brown head, brown or smoky hue thoracic and anal shields, pale legs, and dark spiracles. On the second day, the larva ceases to feed and prepares to shed its first skin. The first moult usually occurs inside the seed in which the caterpillar has burrowed.

Second instar : After the first moult, which takes place on or about the third day after hatching, the larva resumes feeding, either on the same spot of the first instar inside the seed, or on a fresh spot on the seed surface. It goes on consuming the seed matter for two days before casting its second skin.

Third instar : The second moult takes place on the third day from the first moult, and on the fourth day in case of larvae that are reared on lablab pods. The third instar larva either feeds on the old feeding spot inside the damaged seed, or gets herself a fresh spot on the outside. The third instar lasts for two days.

Fourth instar : In most cases, the larva sheds its third skin on the third day after the second moult, but some larvae shed theirs on the second day and others on the fourth day. The fourth instar larvae have reached such a size that they can no longer feed inside the damaged seeds but are always found outside the seeds devouring feverishly great parts of the seeds and are surrounded with grayish pillets of their faeces. Infested pods that contain the fourth instar larvae usually start to show the soft rotten outside appearance du to pod skin disintegration caused by the faeces of the infesting larvae.

Fifth instar : The larva casts its last skin on the third day from the third moult, when reared on cowpeas or sieva bean pods, but when reared on lablab pods it casts its last skin on the fourth day. At this stage the caterpillar feeds on the seeds vigourously, making an extensive network of silken fibers and entangled excrement. If two or three larvae occupy one pod, nothing is left inside the pod except their faeces, thus they are forced to migrate to other pods to feed on their seeds and to complete their development. The larva grows very rapidly and reaches its full size within three or four days after its last moult. Then it leaves the pod and falls to the ground to pupate. The colour of the larva changes to dark pink immediately before pupation.

Larval duration : It varies from 10 to 17 ays, depending on the kind of host plant on which it is reared. On cowpeas and sieva bean pods the larva needs 10 to

13 days to reach its full size and to fall down to pupate, while in case of larvae that are fed on lablab pods the duration may extend to 17 days. Out of fifteen larvae that were bred on cowpeas pods, 3 larvae spent 10 days before pupation, 8 spent 11 days, 3 spent 12 days and one spent 13 days. Another fifteen larvae were reared on sieva bean pods and it was found that 2 larvae spent 10 days, 5 spent 11 days, 6 spent 12 days, and 2 spent 13 days. Out of the fifteen larvae that were bred on lablab pods, 9 spent 13 days, 4 spent 15 days, and 2 spent 17 days.

It is obvious that the nutritional value of seeds content of the different legumes has a certain effect on the larval duration.

FLANDERS, in 1930, stated that the larval duration was two to four weeks for the larvae that were bred on lima beans.

C. During the cocoon and pupal stage

Cocoon and pupation site : As soon as the larva becomes fully developed, it leaves the pod and falls to the ground, where it burrows in the soil under the foliage and starts to spin its cocoon.

In nature, cocoons of *E. zinckenella* are usually found under a depth of 2 to 4 cms. of soil, in a diameter of 20 to 30 cms. from the host plant stem. Sometimes, a few cocoons were found lying right on the soil surface under dry foliage. In the laboratory, twenty fully grown larvae were left in a centigraded glass jar that contained soil to a depth of 10 cms. A few days later the top part of the soil was removed very carefully, in search for the cocoons. It was found that 10 of these larvae had spun their cocoons at a depth of 2 cms. from the soil surface, 7 at a depth of 3 cms., and 3 at 4 cms.

In a trial to find out the effect of more soil covering over the cocoons on the emergence of moths, three groups of cocoons, ten each, were buried under different levels of soil. The first ten cocoons were covered with 5 cms. of soil. Nine moths of these cocoons emerged successfully, while the last moth failed to reach the surface.

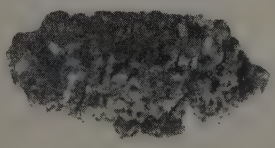

FIG. 15 : Cocoon of *Etiella zinckenella* Treit.

The second group of cocoons was buried under 8 cms. of soil, and in that case four moths succeeded to reach the surface. The third group of cocoons was buried under 10 cms. of soil. In this last case two moths were able to reach the surface, but in a miserable shape. Such observations could be made use of in controlling this pest

by means of raising soil around the plants to cover the area around their stems and so preventing the emergence of the moths and consequently preventing re-infestation which causes extension of the damage of the pest.

The cocoon (Fig. 15) is constructed from soil particles that are tightly cemented together, except at the front end, by fine silken threads. Moth emergence takes place at the front end of the cocoon where the particles are kept quite loose. The pupating larva spends from one to two hours before it completes the cocoon and rests inside it. The cocoon measures from 11 to 15 mms. in length, and from 6 to 7 mms. in width.

Pre-pupal stage : As the cocoon is completed, the larva remains inside it in a quiescent state for a period that depends on the prevailing environmental conditions (see Table VI). The body of the resting larva becomes yellowish green, and shrinks considerably, causing marked constrictions between the segments. Eventually, the larval skin splits and the pupa is disclosed.

TABLE VI

Duration of the pre-pupal stage

Dates of spinning cocoons	Number of larvae	Date of pupation	Range of pre-pupal period in days	Average of pre-pupal period in days	Mean temperature in °C.
31. 5.1953	5	2. 6.1953	2	2	28.2
2–11. 6.1953	37	4–13. 6.1953	1–3	2.2	28.5
8–31. 7.1953	80	10. 7– 1. 8.1953	1–4	1.9	28.7
2–13. 8.1953	34	3–16. 8.1953	1–5	1.9	29.9
9–29. 9.1953	123	12. 9– 4.10.1953	2–7	3	27.1
3–21.10.1953	80	6.25.10.1953	3–6	3.4	25.5
3–16.11.1953	64	7–28.11.1953	3–17	6.5	21.5
26–29.11.1953	11	18.12.1953–13.3.1954	20–107	72	16.4
1–22.12.1953	13	22.12.1953–20.3.1954	16–108	46.8	15.6
18. 2.1954	10	9–12. 3.1954	19–22	20	19

If Table VI is consulted, it becomes obvious that the extent of the prepupal stage depends extremely on the temperature at the time of the transformation. During the hot months of May, June, July and August when room temperature ranges between 28 and 30 °C., the pre-pupating stage only lasted from one to five days before the larvae were actually transformed into pupae. Those larvae that have matured during September and October at a temperature that ranges between 25 and 27 °C., rested for two to seven days before pupation. In winter time, the pre-pupal period of some larvae extended over more than three months.

The majority of larvae that are fully developed during the first half of November may be able to pupate and issue their moths before the end of December. But those larvae that have matured during the second half of November and December

rest until the end of January, or sometime until February, when they become able to pupate and issue their moths during February and March. In other words, most of the cocoons that are found in the soil, during winter time, contain resting larvae. A reverse relation was realised between the extension of the prepupal stage and that of the pupal duration. Whenever the prepupal period is extended, the pupal duration becomes rather short. On the other hand, when the prepupal period is short, the pupal duration lasts longer. Out of 40 resting larvae in winter time, 22 of them pupated within a period of 58 to 108 days and their pupal stage lasted from 24 to 54 days; the other 18 larvae rested for a period of 16 to 51 days and their pupal stage lasted from 30 to 63 days.

Pupal period : Duration of the pupal period depends on the temperature that prevails at time of pupation. It may last from one to nine weeks. During summer time, the longest pupal period, among 260 pupae, was 19 days, while the shortest was 7 days. During winter time, the longest pupal period among 73 pupae was 63 days, and the shortest was 18 days (see Table VII).

TABLE VII

Duration of the pupal stage

Dates of spinning cocoons	Number of larvae	Date of pupation	Range of pré-pupal period in days	Average of pré-pupal period in days	Mean temperature in °C.
18–27.12.1953	12	16–22. 2.1954	60–63	61.5	14.9
17–31. 1.1954	20	16. 2–23. 3.1954	30–55	48.2	16.5
13–25. 2.1954	16	24–31. 3.1954	32–39	36.7	17.9
1–20. 3.1954	25	29. 3–13. 4.1954	24–31	28.2	19.2
4–13. 6.1954	36	14–24. 6.1954	9–14	10.7	29.5
10–31. 7.1954	64	18. 7–10. 8.1954	7–12	9	29
1–15. 8.1954	37	10–27. 8.1954	8–11	9.6	29.3
12–30. 9.1954	73	23. 9–13.10.1954	10–14	11.7	26.5
1–30.10.1954	80	12.10–12.11.1954	11–19	14.5	25.2
7–26.11.1954	44	26.11–18.12.1954	18–33	25.8	19.4

According to FLANDERS (1925), pupation of the summer brood may occur during August and September, but many of the resting larvae may overwinter. Again FLANDERS (1926) has claimed that pupation of the over-wintering brood may occur at any time during winter season, but most of the brood enters the pupal stage during March and April. Pupation of the spring brood occurs from April to September, but for the most part in May and June.

LEONARD and MILLS (1931) in Porto-Rico, made observations on the length of the pupal period. They found that nine pupae took 9 to 14 days to emerge early in June, and 10 pupae spent 9 to 12 days in August.

Beside the effect of temperature on the duration of the pupal period, it seems that temperature has a certain effect on emergence of moths. It was noticed that a good percentage of winter moths fail to emerge from their pupae due to low temperature; larvae that pupated during December issued moths from only 40% of their pupae, those that pupated during February gave 50% moth emergence. During January, moth emergence was quite hight as it occurred in 90% of the the pupae. March brood was the most successful, from the standpoint of moth emergence, not a single moth, out of 25 pupae, failed to emerge. Pupae of summer brood gave a good percentage of moth emergence that ranged between 87% in the July brood to 91% in the October brood (Table VIII). The succumbing pupae that failed to emerge were shrunken, dry, and in no case was death related to the effect of parasitism.

TABLE VIII

Moth emergence at different months

Pupation time	Number of pupae	Number of moths emerged	Percentage of emergence	Mean temperature in °C.
January	20	18	90	16.5
Februay	16	8	50	17.9
March	25	25	100	19.2
July	77	67	87	29
August	40	37	92.5	29.3
September	87	74	85	26.5
October.....	90	82	91	25.2
November.....	60	52	86.7	19.4
December	10	4	40	14.9

D. During the moth stage

Emergence : When the moth is ready to emerge out of its pupal case, it pushes its way through the tender area at the front end of the cocoon. As previously mentioned, the moth is capable of emerging and pushing its way through a depth of soil up to 8 mm., especially when such soil is of loose particles. Some moths exerted such an effort to reach the surface that they died before they had time to show any activity. Healthy looking moths that just emerged cleaned themselves for awhile before starting to hop or to make short flights inside the breeding jar.

Sex determination and ratio : The sex of a moth could be determined by examining its antennae. It has been mentioned that the pedicel of the male antenna is dilated into a sinus form and the curved second flagellar segment is provided with a thick tuft of hairs, while the female antenna lacks both the sinus and the tuft of hairs. On the other hand, when the female moth is at rest, the distal segments of the labial palpi keep apart, leaving a V-shape space, while in the male moth, the same

segments run in a closely parallel manner. This is beside the fact that the body of a male moth is slender and more or less cylindrical in shape and in the female it is stout and conical.

Sex of moths during summer time was rather equal, with a slight tendency towards the male sex : about 53% for the male sex and about 47% for the female sex. This sex ratio was reversed in moths that emerged during September, as shown in Table IX.

TABLE IX

Sex-ratio of moths at different months

Time of breeding	Number of larvae	Number of male moths	Number of female moths	Percentage of male moths	Percentage of female moths
July	207	111	96	53.6	46.4
August.....	256	136	120	53.1	46.9
September .	219	102	117	46.6	53.4
October.....	249	132	117	53.0	47.0
November .	153	93	60	60.8	39.2

Longevity of moths : Twenty pairs of virgin moths were kept in separate cages that were provided with 5% sugar solution. The life span of the male moths ranged from 8 to 20 days, while that of the females from 9 to 20 days under a mean temperature of 25.8°C. Under such condition, the life span of both sexes seems to be similar, contrary to FLANDERS' findings (1930), who showed that the average life span of the males, fed with a dilute solution of brown sugar, was 22 days and that of the females was 25.5 days. Under the same condition, ten other non-fed virgin pairs survived 6 to 12 days for male moths and 8 to 14 days for female moths.

This suggests that nutrition has a certain effect on the life span of the moth, causing it to extend for several days in both sexes of moths. Mated moths lived less days than virgin moths, provided that all of them were fed with the sugar solution. The life span of mated moths lasted from 7 to 11 days in case of male moths, and from 5 to 11 days in case of female moths. In this case the moth longevity was cut short, due to the exertion of the moths during the mating process.

VII. ANNUAL CYCLE AND FLUCTUATION

Annual cycle : *Etiella zinckenella* bred under laboratory conditions gave seven to eight generations in a year. Observations in the field of the different stages of the pest gave the impression that the pest might have six to seven generations per annum. The first generation is expected in the early spring during the end of February

and the beginning of March, the moths of which emerge from the hibernating pupae. Such moths lay their eggs on pods of lablab and spartium which become infested by the larvae of the pest during the three months of spring. Other hosts which have been suggested, by the authors, to be hosts for *E. zinckenella* at that time of the year, were inspected very thoroughly and in different localities. Pods of broad beans, peas, lupine, lathyrus and pigeon peas were not found under any circumstances to be infested with larvae of *E. zinckenella*. Pods of peas and lupines were, sometimes, found infested with larvae of the butterfly *Cosmolyce baeticus*. One or two generations may occur on the pods of lablab, and then moths issued from such pods start to lay their eggs on pods of cowpeas and sieva beans that are cultivated early in summer during May, June and July. One or two generations may take place on the early summer cowpeas and sieva beans. In Egypt, cowpeas and sieva beans are usually cultivated late in summer, after winter crops. During August, September, and October the pods of cowpeas and sieva beans are severely infested by the larvae of *E. zinckenella*, and two to three generations may develop during that period. On the approach of cold weather in November most of the larvae, that do not reach their maturity, stay in a quiescent state, but those larvae that reach maturity pupate and spend winter time as pupae. Under any spell of warm weather some of these pupae may be able to emerge and give off their moths, and these may lay their eggs on lablab pods during November, December and January. The two kinds of cocoons that contained resting larvae and pupae were treated similarly during winter time by keeping them in an incubator under 25 °C. and with enough humidity. In a matter of 5 to 7 days moths emerged from the cocoons that contained pupae. Other cocoons that contained resting larvae failed to do so, after a period of two weeks. It is evident that the pods of lablab that continue to develop during the six months of winter and spring offer two chances for the survival of the pest; the first chance is that offered to the issuing moths during November, December and January to lay their eggs on lablab pods; other hosts are lacking at that time. The second chance is that the lablab pods serve as a host for the larvae of the pest until the time comes when other hosts become available and so give the pest a chance to continue its development without a break.

Fluctuation : Fluctuation of the pest was estimated in cowpeas and sieva beans during the two periods of the early summer and the late summer cultivations.

As previously shown in Table I, degree of infestation on cowpeas was estimated in Embaba five times during the period between the 23rd of June and the 7th of August. The different estimations of infestation were 5% on June 23rd,4% on July 2nd, 5.3% on July 8th, 6% on July 20th, and 15.5% on August 7th.

The other five estimations of infestation were carried out on the late summer cowpeas pods in the Giza locality, during the period between September 12th and October 16th. Such estimations were 22.7% on September 12th, 32% on September 16th, 43.3% on September 26th, 16.7% on October 6th, and 36.7% on October 16th.

The authors did not have the chance to find sieva beans that were cultivated in the early summer in the nearby localities, so the fluctuation of the pest was only estimated on sieva beans that were cultivated late in summer (nili). Five estimations were carried out during the period between September 13th and October 14th in the Giza locality. These estimations were 43 % on September 13th, 26 %. on September 15th, 30 % on September 25th, 22 % on October 4th, and 18 % on October 14th.

From the three previous fluctuations of the pest in cowpeas and sieva beans, the following points can be deduced concerning infestation of the pest.

1. — The crop of the early summer cultivation of cowpeas is much less liable to the infestation than that of the late summer cultivation, the loss reaching 15.5 % in the first crop, while it increases to 43.3 % in the second crop.

2. — The maximum degree of infestation during the early summer cultivation takes place late in the season of cultivation while in the late summer cultivation the maximum degree occurs in the middle period of cultivation.

3. — In the case of sieva beans the highest infestation takes place at the beginning of the pod formation, and then it declines gradually.

4. — If the infestation on cowpeas and sieva beans are compared with each other, a very interesting observation will surely pop out. In the case of cowpeas there is a peak followed by a drop, while in sieva beans infestation starts with a drop which is followed by a peak. In other words, the fluctuation of the pest in the two crops is exactly reversed, i.e. when degree of infestation is rising in cowpeas, it declines in sieva beans, and vice-versa.

VIII. PARASITES

FLANDERS (1930) found that two braconid wasps of the genus *Microbracon* attack the larvae of *E. zinckenella*. The same author found that the chalcid *Zatropis tortricidis* attacks the partly grown larvae. WOLCOTT (1934) found a single instance of parasitism by *Trichogramma minutum* among other hundreds of eggs. KLINKOWSKI (1939) discovered a few larvae that were parasitised by *Pimpla roborator*.

The writers were not able to disclose parasitism on *E. zinckenella* until very late in the season. At the middle of November, when most of the cowpeas pods were getting dry, a good number of pods were getting dry, a good number of pods that were infested were found to contain cadavers of fully grown *E. zinckenella* larvae Around such cadavers, larvae of *Pimpla roborator* were roaming. In one or two days larvae of *P. roborator* pupated and the wasps emerged after 10 days under 25 °C.

IX. SUMMARY

1. — Study of the external morphology and biology of the bean pod-borer, *Etiella zinckenella*, is suggested to get a better understanding about a serious pest that hinders the cultivation of cowpeas and lima beans in Egypt.

2. — Different synonyms of *E. zinckenella* are disclosed; also the distribution of the pest all over the world, as well as its distribution at different localities in Egypt, is shown.

3. — In Egypt, lablab and spartium are the main wild hosts of the pest, while cowpeas and lima beans are the main cultivated crops that suffer from the ravages of the pest. Lupines, broad beans, pigeon peas and other hosts that are found to be hosts of the pest by other authors are not found to be so in Egypt.

4. — Descriptions of the external morphology of the different stages of the pest are included : size, shape and reticulations on the chorion of the egg; size, colour and width of head capsules of the different larval instars; cocoon and pupa; size, colour, sex determination and genitalia of the moth.

5. — Biological processes of the pest in its different stages were studied carefully, and the following points are included :

(*a*) Copulation takes place one or two days after moth emergence and the coitus process is described.

(*b*) Oviposition continues for two to seven days and the eggs are laid on the apical shoots of the plants, but mostly on the blossoms and the newly shedded pods. The process of oviposition is described.

(*c*) Character and damage caused by each of the five larval instars are shown. Some pods may be secondarily infested by grown larvae that have migrated from their primarily infested pods due to exhaustion of food. The two types of infestations are manifested.

(*d*) Late in the season fully grown larvae may enter a pre-pupal quiescent stage that may extend through the winter time to pupate and emerge at the warm weather in spring.

(*e*) Pupation takes place in the soil at a depth of 2 to 5 cms., within a range of 20 to 30 cms. around the plant stem. The pupating larva spins a cocoon that is lined with white fine fibres and coated with soil particles, except at the front end where it is left loose for the emergence of the moth.

(*f*) Sex determination and ratio of the moths are determined; male antennae are stouter and more hairy at their base than the female antennae; also the third segments of the labial palps run parallel in the case of the male moth and diverge in the case of the female moth. Sex of moths is rather equal, with a slight tendency towards the male sex.

6. — Some of the winter pupae fail to emerge as they become dry and shrivelled with no sign of disease or parasitic attack. Parasitism on the larvae of the pest takes place late in the season by the Ichneumonid wasp *Pimpla roborator*.

X. ACKNOWLEDGMENT

The greater part of this work was carried out in the Department of Plant Protection and the experimental field of the Faculty of Agriculture, Cairo University.

The authors wish to express their gratitude to Prof. Dr. AHMED SALEM HASSAN, Head of the Department, for his advice and for offering departmental facilities. Thanks are also due to Prof. Dr. ABDEL GAWAD HASSAN. Head of the Department of Plant Protection of the Faculty of Agriculture, Ain Shams University, and to Mr. A. ALFIERI, Secretary General of the Entomological Society of Egypt.

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CONTRIBUTION TO THE BIOLOGY AND BIOCHEMISTRY OF THE COTTON LEAF-WORM, *PRODENIA LITURA* F.

I. Investigations on the duration of the pupal stage and on the emergence and its relation to the daytime of female and male moths.

(with 4 Text-Figures)

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and

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CONTENTS

I. Introduction. — II. Material and method. — III. Investigations on (a) the duration of pupa stage, and (b) on the emergence and its relation to the daytime of female and male moths. — IV. Discussion. — V. Summary. — VI. Acknowledgment. — VII. References.

I. INTRODUCTION

Exogenous factors and endogenous rhythms influence the duration of the pupa stage and of the emrgence of insects in relation to the daytime. The present investigations are only phenomeno-logical. They should demonstrate only a relationship between daytime and the emergence of *Prodenia litura* F. . Such observations should aid in the control of the Cotton leaf-worm by sex-attractants of the female moths.

It is well-known, that many Lepidoptera are emerging in different day- and night-times. Some Rhopalocera and Sphingiidae emerge in the morning and Noctuidae in the evening (SPULER). According to GOETZ, the time of emergence of

Bombyx mori is between 7 and 9 a.m. as well as between 8 and 9 p.m., of *Sparganothis pilleriana* especially between 8 and 9 a.m. as well as between 8 and 9 p.m. BREMER observed, that the night-active moths of *Ephestia kuehniella* prefer to emerge during the hours in the afternoon and in the evening. According to WIESMANN, *Prodenia litura* F. should emerge in every day- and night-time. We, however, observed in our laboratory-breeding a dependence of the emergence, which is rhythmically bound to the day-time. WIESMANN also describes a Protandrie on the *Prodenia litura* F., which is the contrary of our results. Therefore, we have examined our observations and the results are given hereunder.

II. MATERIAL AND METHOD

Larvae of the 4th till 5th instar were kept in big wire-gauze cages on a layer of saw dust and were fed till the pre-pupae with castor-oil leaves. The pre-pupae of one breeding were taken over in separate cages and within one night they became pupae, sometimes in their own cocoons, while sometimes they were lying right on the saw dust.

The new pupae, which are translucent at the beginning, were taken off from their cocoons and carefully brought in new cages containing moistened saw dust, where they rested at normal relative air-humidity and constant temperature until the moths emerged. In day-time, they were kept in damped light and at night-timein rooms completely dark.

Each pupa, before sexually separated, was registered from the time of pupation until emergence of the moths. The emerging imagines were observed during 96 hours, and partially registered each 30 minutes because of lack of a counting GOETZ watch. At the same time, a thermo-hydrograph registered the temperature and the relative humidity.

III. INVESTIGATIONS

(a) On the duration of the pupal stage

The duration of the pupa stage is mainly influenced by the temperature and the relative humidity. The effect of the light should be minor. The climate during our investigations was kept as steady as possible. It showed, that on an average the males emerged one day later than the females (Fig. 1).

The different duration of the pupa stage in both sexes as found by us, was confirmed by another measure with a bigger amount of material (Fig. 2).

(b) On the emergence of the imagines, rhythmically bound to the day-time

It seems that light is the most important factor of all exogenous factors which influence the emergence rhythmically bound to the day-time. The importance

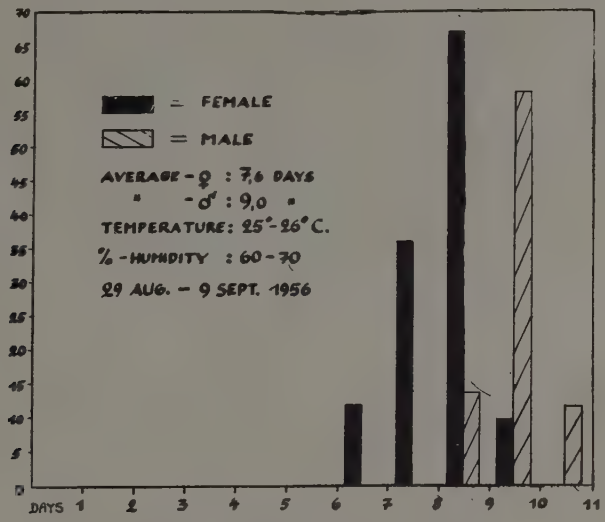

FIG. 1 : Time of emergence from pupae.

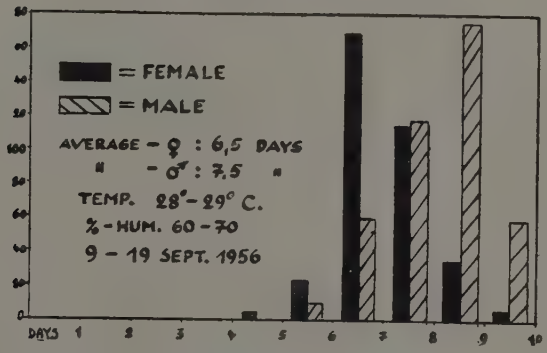

FIG. 2 : Time of emergence from pupae.

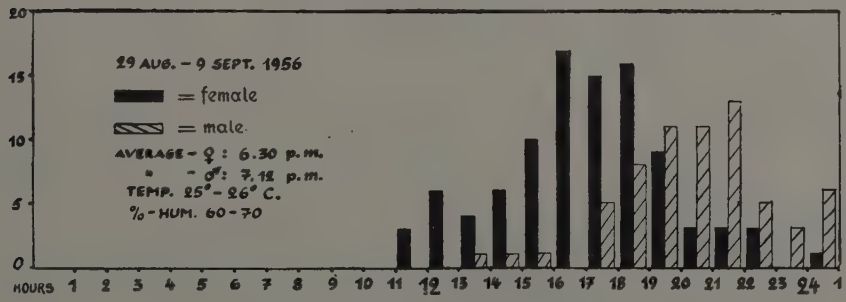

FIG. 3 : Day-time of emergence from pupae.

of the humidity is estimated as inferior (REMMERT). So, for instance, a post-poned emergence-maximum could already be obtained by inversion of the lighting-time (BUENNING, KALMUS). Also, according to GOETZ, the effect of light is more important to the emergence, rhythmically bound to the day-time, than to the influence of humidity. Therefore, our records were always made in damped light or in full dark. They showed that the females emerge generally one hour earlier than the males (Fig. 3) :

The earlier emergence of the females became more evident in the following registration with collectively 347 imagines (Fig. 4).

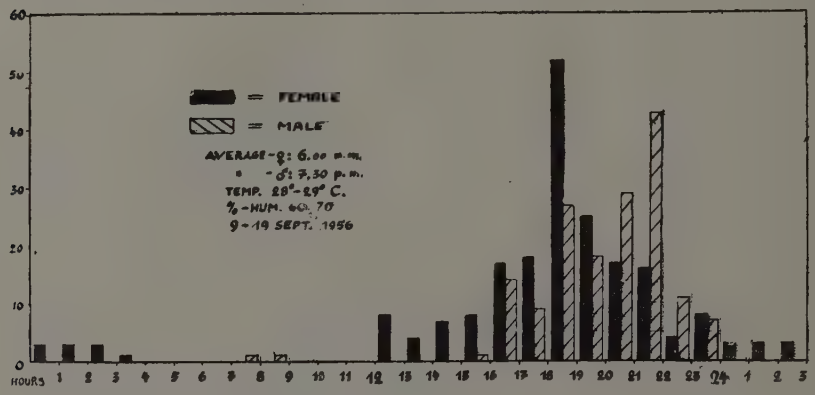

FIG. 4 : Day-time of emergence from pupae.

IV. DISCUSSION

BISHARA refers in his extensive publication a pupa stage of *Prodenia litura* F. of generally 7 days at 28-29 °C. According to WILLCOCKS "from March to November inclusive, the pupa stage lasts from ten days to three weeks, including the prepupa stage. In summer, in the breeding cages, the pupa stage may be as short as seven days; but between 10 and 14 days is nearer to an average period". Both authors did not differ from the pupa stage of male and female. We found, in our laboratory investigations, similar values. But it showed that the females have a shorter pupa stage than the males on the same breeding. The difference was generally one day.

In the introduction, we have referred to the observation that the emergence of many Lepidoptera is rhythmically bound to the day-time. WIESMANN did not observe an emergence and its relation to the day-time on *Prodenia litura* F. In his laboratory breedings during winter, the moths emerged at all day- and night-times. We, however, found that from the 29th of August to the 19th of September 1956, the females leave their pupa cases between 11 a.m. and 3 a.m., with a culminating

point of emergence from 6 p.m. to 8 p.m. The time of emergence of the males was between 1 p.m. to 1 a.m., with a maximum from 8. p.m. to 10 p.m. We cannot confirm the Protandrie described by WIESMANN, neither the duration of pupa stage nor the emergence rhythmically bound to the day-time during the summer. The fact, that females emerge sooner than males, could be of great importance for the control of *Prodenia litura* F. pest in the practice by the attraction of males with the sexual scent of females. The earlier beginning of male-flight is already experimentally proved by WIESMANN, and will be in future also of great importance.

V. SUMMARY

The duration of the pupa stage of *Prodenia litura* F. and the emergence and its relation to the day-time on male and females moths were investigated in the laboratory from 29th of August to 19th of September, 1956.

The pupa stage lasted on an average, at 25-26 °C. : for the females 7.5 days and for the males 9 days. At a temperature of 28-29 °C., the pupa stage lasted for the females 6.5 days and for the males 7.5 days on an average.

A rhythmically emergence, bound to the day-time, was detected on both sexes. The female moths emerged between 11 a.m. and 3 a.m., with a culminating point of emergence from 6 p.m. to 8 p.m. The male moths emerged between 1 p.m. and 1 a.m., with a culminating point of emergence from 8 p.m. to 10 p.m. Generally, the female moths leave their pupa cases one hour earlier than the male moths. The Protandrie, observed by WIESMANN during winter, cannot be confirmed by us during summer.

VI. ACKNOWLEDGMENTS

For the collection of the material in the cotton field during the season, as well as for the support for our research work on *Prodenia litura* F., we express our best thanks to Messrs. IBRAHIM BISHARA and MOSTAFA HAFEZ, as well as to the staff of the Parasitology Laboratory, Ministry of Agriculture, Cairo.

We are also much obliged to the GERMAN RESEARCH ASSOCIATION, Bad Godesberg bei Bonn, Germany, for their aid and interest in our research.

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POPULATION STUDIES ON THE BLACK SCALE, *CHRYSOMPHALUS FICUS* ASHMEAD:

I. THE DISTRIBUTION OF POPULATION IN A WILD INFESTATION

[*Hemiptera-Homoptera* : *Coccoidea*]

(with 14 Text-Figures and 9 Tables)

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Faculty of Agriculture, Ain Shams University, Cairo.

CONTENTS

I. Summary. — II. Introduction. — III. Sampling method. — IV. Methods of analysis. — V. A comparison between means of different counts. — VI. The effect of heights and directions on the distribution of pupulation. — VII. References.

I. SUMMARY

The present study comprises the result of analysing counts of the black scale insect infesting trees of *Ficus nitida*. Counts were carried out on two ecologically different trees; one exposed to the sun from all directions (sunny tree), the other closely surrounded by other *Ficus* trees (shady tree).

Under our local conditions, the population density of the black scale insect reaches a very high level in March-April when compared with counts carried out in November-December and July-August. Moderate temperature with low humidity, therefore, are much preferred by this insect rather than high humidity with either low or high temperature.

In November-December, the population is evenly distributed on the sunny tree and in most components heights and directions do not play any part in the orientation of the population. Only in case of the total number of males, number of living males and percentage of survivors among females means were significantly arranged from down upwards according to order of magnitude. In the shady tree both factors, heights and directions, proved to be extremely effective in the distribution of population. Nearly in all its components the highest mean occurred in the upper most zone of the tree and the gradation was clear from up downwards. With regard to directions there was always a tendency for the highest population to occur in the SW. or W. directions and the least population in NE or NW. Moreover, the southern hemisphere of the tree which was generally longer exposed to sun rays harboured more insects than the northern hemisphere.

In March-April the upper most part of the sunny and shady trees tended to harbour the highest mean of the total population and total number of nymphs, while the lowest mean occurred at the bottom of both trees. With regard to directions the peak of the population occurred in the SE and there was a gradual decrease towards the opposite direction (NW) which contained the lowest mean. In the shady tree the southern hemisphere harboured more insects than the northern hemisphere.

In July-August, the sun rays being approximately perpendicular, there was a negligible effect of directions on the distribution of population in both sunny and shady trees. Moreover, both extremities of the sunny tree received heat in the same intensity, the upper by radiation and the lower by reflection from the hot unshaded sandy soil below. This resulted in an even distribution of the population in different heights. But still the temperature in the middle zone of the tree became comparatively mild causing some components of the population to accumulate in it. The top of the shady tree received direct sun rays, but the lower parts were shaded. This caused the means to be reversed, the highest mean occurred at the bottom of the tree where temperature was mild and the lowest at the top where temperature was detrimental.

The inter-actions between different factors affecting the population density in different seasons will be dealt with in a separate paper.

II. INTRODUCTION

The distribution of the black scale insect on any particular tree is best carried out on a wild population that has been left unchecked for several years. The build up of the population will then be controlled by factors, biotic or physical, the resultant of which will be shown in the orientation of the population. But if these factors have no such effect the population will be evenly distributed on the tree irrespective of heights and directions. But this is practically not the case as the insect shows

a particular distribution not only on trees of *Ficus nitida*, a common host in our country, but also on citrus trees especially towards the end of the hot season, August and September.

The uneven distribution of the population of the black scale insect on a single tree as well as on different trees throughout a given orchard, and the already established fact that the insect is much more common in the Nile-Delta and northern parts of Upper Egypt than in the southern parts (PRIESNER, 1931) made it necessary to study the ecology of this insect. The economic outcome of such work needs not be emphasized.

It has been shown by SCHWEIG and GRUNBERG (1936) that the black scale shows a preference for settling in shade during hot months and on the sunny side of trees during the cooler period of the year. But whether these changes of distribution are due to an active migration of crawlers or the result of an increased mortality of nymphs exposed to the influence of direct sun rays, is not yet ascertained. Nor is it clear whether the build up of a population on citrus trees after applying control measures is brought about by migration of crawlers from untreated trees or is it due to the reproductive potentiality of survivors. The experiment of SCHWEIG and GRUNBERG in which they left an untreated tree among other fumigated ones in order to ascertain the direction of the new infestation showed that in the encircling trees the highest infestation was lying in the west and north-west directions of the centre of the infestation. Had the crawlers been disseminated by wind the highest infestation would have been in trees lying east or south-east to the centre of infestation as western winds were prevailing. BODENHEIMER (1951), nevertheless, did not discard the importance of wind as carrier of crawlers.

The present work is an attempt towards the study of the ecology of the black scale insect in an infestation that has been left unchecked for several years. It describes the distribution of the population in different heights and directions on trees of *Ficus nitida* and follows out its dynamics throughout the different seasons.

III. SAMPLING METHOD

A park containing over 200 tall trees of *F. nitida* was put under observation. Two infested trees of approximately the same height (9-10 m.) and diameter (8-10 m.) were chosen. One was closely surrounded by other trees and shaded from nearly all all directions (shady tree), and the other was in an open side of the park exposed to the sun from all directions (sunny tree). Samples were taken from the terminal parts of the branches at eight directions : North (N), North-east (NE), East (E), South-east (SE), South (S), South-west (SW), West (W), North-west (NW) and at the central point of the tree (C.). This was carried out at 6 heights : 3, 4, 5, 6, 7 and 8 m. The sample contained several leaves, but because they were unusually heavily infested counts were made on ten leaves which were chosen to represent the sample. Thus at every height insects on 90 leaves were counted and sorted according to the following

items, and in one count 540 leaves were examined. Considering that the population density was estimated three times during 1955-1956 on each tree, it can be observed that the results shown in this work are the summary of a bulk of data which were obtained from population counts on 3240 leaves of *Ficus*.

Eight items were recorded : (1) nymphs, (2) dead nymphs, (3) ovipositing nymphs, (4) non-ovipositing females, (5) ovipositing females, (6) dead females, (7) males, (8) dead males.

Parasitized individuals and those attacked by predators, were also counted. Counts were made on both trees during three different intervals : the first in November-December 1955, the second in March-April, and the third in July-August, 1956. These intervals corresponded to three different seasonal temperatures (Fig. 1).

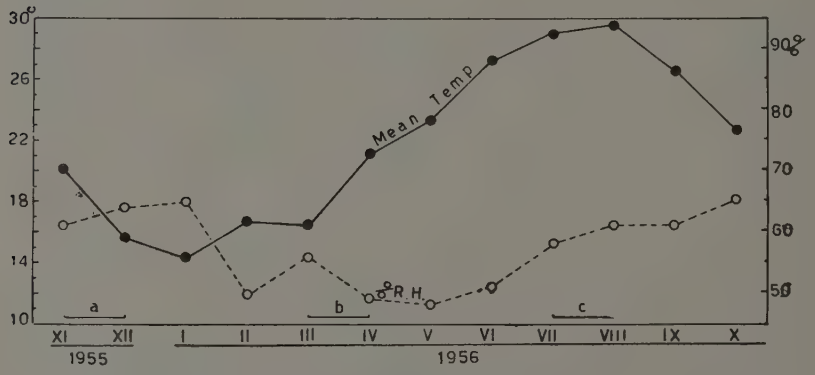

FIG. 1 : Mean temperature and relative humidity from November 1955 to October 1956 (a, b, c are counting periods).

It has to be noted that female individuals, the scales of which were devoid of the black zone, were taken as nymphs. The pre-pupae and pupae of the future males were considered as immature stages although the black zone had made its appearance. When the male is fully formed it moves out of its shell and the scales do not remain long on the leaves compared with those of females. Therefore, the number of male shells does not give the real number of males, and any attempt to deduce the sex-ratio through the number of male and female scales would be open to criticism. But, assuming that the drop of male shells is more or less constant throughout the different counts, their numbers would be relevant to the real number of males.

Empty male shells were considered as representing living males, because the male moves out of the shell for one reason and predatism was very rare among the population for another. The numbers of eggs and crawlers were disregarded.

IV. METHODS OF ANALYSIS

For studying the effects of heights and directions on the distribution of the total population and its constituents on the trees, the data of the three counts were subject to the following scheme of statistical analysis :

1. — Simple analysis of variance for the numbers of insects occurring on ten leaves in the six heights and nine directions referred to above. The percentage of survivors among females and nymphs and also the number of parasitized insects were also subjected to this analysis.

2. — When the result of this analysis was significant for either heights or directions or for both at 5% level of significance the least significant difference (L.S.D.) was estimated to separate off differing criteria.

3. — When the result of the analysis of variance was significant but the L.S.D. did not separate successive means of heights or directions arranged in order of magnitude careful sub-analysis using TUKEY'S formulae was carried out (TUKEY, 1949).

$$\frac{\frac{(m - m')}{\sigma} \cdot 6 \log_{10} K}{3\left(\frac{1}{4} + \frac{1}{n}\right)} \text{ for means} > 3 \text{ or } \frac{\frac{(m - m')}{\sigma} \cdot \frac{1}{2}}{3\left(\frac{1}{4} + \frac{1}{n}\right)} \text{ for 3 means}$$

where m is the mean, m′ is the mean of means, K is the number of means, σ is the standard error and n is the number of degrees of freedom for the residual variance in the analysis of variance.

V. A COMPARISON BETWEEN MEANS OF DIFFERENT COUNTS

If the mean of 54 samples taken from 6 heights and 9 directions is each tree is estimated, then the figure obtained represents the population per 10 leaves for the whole tree. The figures obtained from the three counts for both the sunny and shady tree are given in Table I.

When comparing the means of the three counts, it is evident from Table I and curves (Fig. 2), that the highest total population is in the March-April count where it is 2651 and 2861 insects per ten leaves in the sunny and shady tree, respectively. The numbers for November-December count are much higher than those for July-August count; they are undoubtedly greatly affected by the prevailing weather conditions both during the period in which the count was made and during the preceding generations. It is clear from the curves of temperature and humidity (Fig. 1), that the period of March-April and the days preceding it are characterised by moderate temperature (16.4 - 21.1°C.) and low humidity (55.8-49.1%), whereas the periods of November-December and July-August are characterised by low and

high temperatures, respectively, and high humidities in both. All items constituting the total population follow this rule with very few exceptions, i.e., the number of dead adults and dead females on the shady tree where the numbers of July-August

TABLE I

Mean number of insects per 10 leaves.
Each mean is taken from counts of 54 samples (6 heights × 9 directions) comprising 540 leaves.

Items	Nov.-Dec. 1955		March-April 1956		July-August 1956	
	Sunny	Shady	Sunny	Shady	Sunny	Shady
Total population	2210	1705	2651	2861	796	1470
Total No. of nymphs .	1504	1180	1719	1814	418	786
No. of dead nymphs....	1120	933	1097	1157	360	713
No. of living nymphs ..	384	247	622	657	58	72
Total No. of adults.....	707	519	932	1047	379	685
No. of dead adults	272	218	432	506	246	559
Total No. of females .	300	179	682	662	248	510
No. of living females ..	141	71	379	376	43	49
No. of living ovi-females	72	24	210	218	8	25
No. of dead females ..	158	108	303	286	204	461
Total No. of males ...	410	340	251	383	131	175
No. of living males	294	230	122	164	89	76
No. of dead males ...	114	110	129	219	41	99
Perc. surv. of nymphs .	24	19	35	31	17	11
Perc. surv. of females .	44	34	57	57	11	8
No. parasitized insects..	—	—	61	58	12	25

count are higher than those of the other two. These two exceptions, however, show clearly the unfavourable effect of high temperature on the insect during the summer season. Thus a general rule could be easily deduced, *that this insect prefers zones of moderate temperature with low humidity, rather than high humidity with either low or high temperature.*

A stronger evidence of this statement could be obtained when comparing counts of the sunny and shady tree, bearing in mind that the sun as a source of heat tends to raise the temperature of foliages up to 8°C. above the surrounding air in summer (SMITH, 1954). In March-April count or, in other words, during the season of moderate temperature, the numbers of insects on the sunny and shady trees are very nearly equal with a slight inclination in the sunny counts to be always less than those in the shade; an outcome of the higher probably unfavourable temperature prevailing on the surfaces of the leaves exposed to the sun. The numbers in the other two counts are clearly different from one another both in the sunny and shady trees, and are also reversed to each other. In November-December count or in the cold season, the numbers of insects in the sunny tree are much higher than those in the

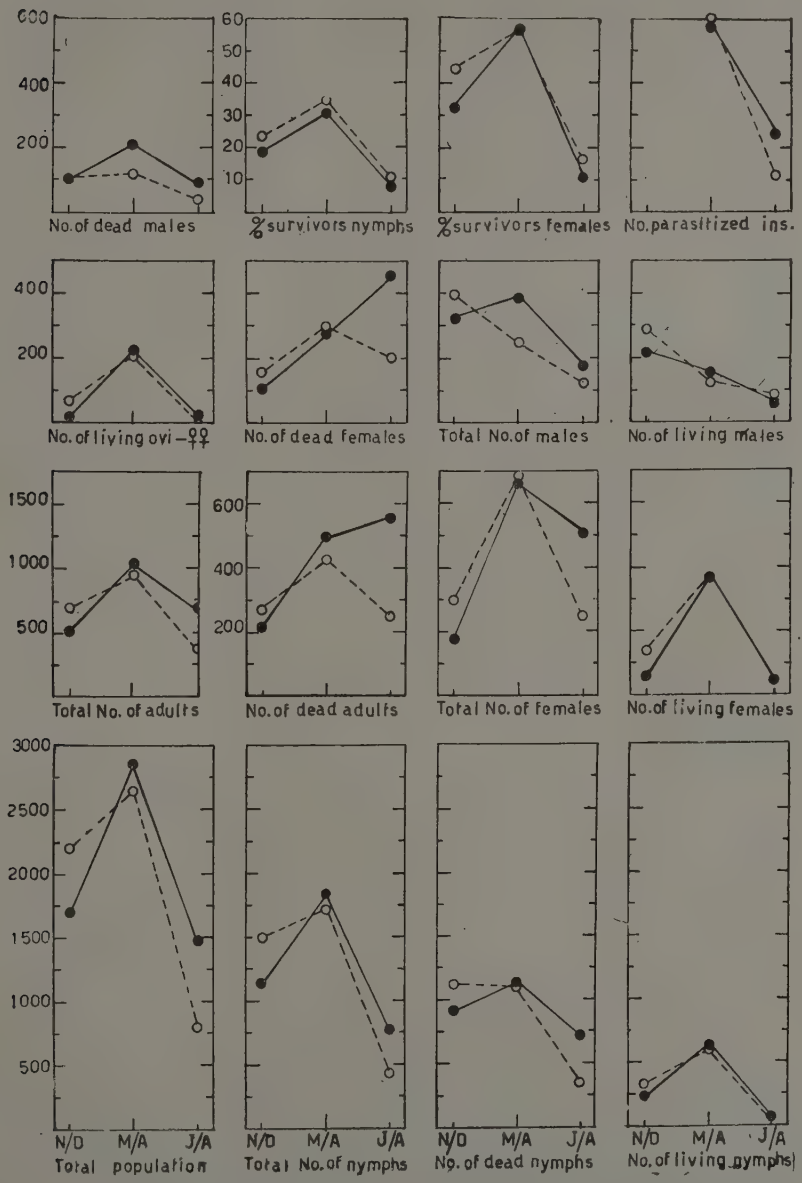

FIG. 2 : Mean number of insects per 10 leaves (the unbroken line represents the shady tree, the broken line represents the sunny tree).

shady, and this is undoubtedly a response to a higher but favourable temperature at this time of the year. In July-Agust the reverse is true, the numbers of the shady tree being clearly higher than those of the sunny; another proof for the moderate temperature preferred by this insect.

VI. THE EFFECT OF HEIGHTS AND DIRECTIONS ON THE DISTRIBUTION OF POPULATION

November-December count

The F values of the different items are given in Table II, using the symbol (—) for the insignificant values and the symbols (+) and (++) for significant values at P levels of 5 and 1%, respectively.

TABLE II

November-December count. The result of analysis of data (—, difference berween means is insiginificant; +, result is significant at P level of 5%; ++, result is significant at P level of 1%). The difference in those marked with an asterisk is significant at 10% level.

Items	Heights		Directions	
	Sunny	Shady	Sunny	Shady
Total population	—	++	—	++
Total No. of nymphs	—	++	—	++
No. of dead nymphs.....	—	++	—	++
No. of living nymphs	—	++	—	+
Total No. of adults.....	—	++	—	++
No. of dead adults	—	++	—	++
Total No. of females	—	++	—	+
No. of living females	—	+	—	—
No. of living ovi-females ...	—	++	—	—
No. of dead females	—	++	—	++
Total No. of males	+	++	—	++
No. of living males	+	++	—	++
No. of dead males	—	++	—	+
Perc. surv. of nymphs	—	+	—	—
Perc. surv. of females	+	++	—	+

a. Sunny tree

A look at Table II shows the unappreciable effect of both heights and directions in case of the sunny tree. This tree is exposed during this cold season to almost low temperatures, the variations between the different heights and directions being insignificant to the build up of the population. But in different heights the means of total males and living males were significantly different. Their succession was

(6-8-7-4-5-3) in the former and (8-6-7-4-5-3) in the latter with no grouping. But, if we consider that the difference between the means at 8, 7, 6, 5 and 4m. height was not significant in both cases, it can be observed that the numbers of total and living males tend to increase from down upwards. In the percentage of survivors of females the means were divisible into two separable groups : 8 - (4-6-5-7-3), the highest mean was at 8 m. height and the lowest at 3 m. height; the means in the second group were insignificantly different. Result is graphically represented in Figure 3.

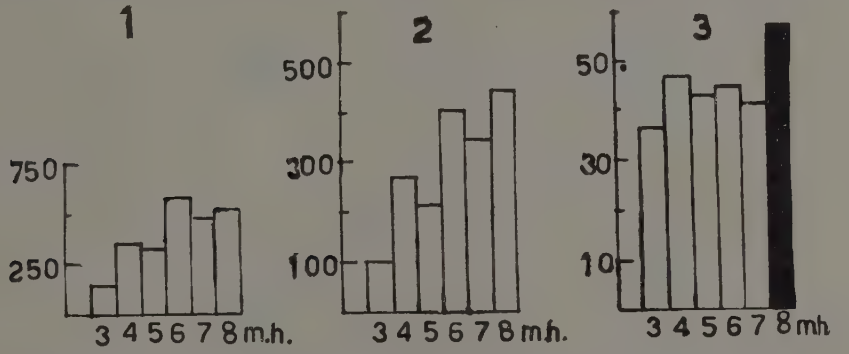

FIG. 3 : November-December count, sunny tree. Mean number of insects per 10 leaves in different heights. Inseparable means are given the same shade : (1) total number of males, (2) number of living males, (3) percentage survivors of females.

b. Shady tree

Both factors, heights and directions, proved to be extremely effective in the distribution of population. The insects followed in this case the more favourable zones of the tree. It was found more convenient to summarize the results of analysis of data in Table III. The significantly different means (at each height there are 9 directions and at each direction 6 heights) are arranged in order of magnitude, starting with the highest mean. Inseparable means are put between brackets. In the second column of the Table numbers show the heights in metres, but directions are given in the third column according to their symbols. These results are also graphically illustrated in Figures 4, 5 and 6.

With regard to heights, there is always a tendency for the highest population to occur in the upper most zones of the tree. Thus, in the case of the total population, the means were divisible into two groups, namely (8-6-7-5) and (4-3), respectively. Although the means within each of these two groups were statistically inseparable yet the gradation in each case is clear to be from up downwards. The same phenomenon nearly applies to all items constituting the population, with very slight deviations. A satisfactory explanation for such distribution may be obtained from the fact that the sun rays in this cold season are in their maximum inclination (23°). The heat caused by radiation should be greater in the uppermost exposed parts of the

tree than in the lower shaded parts. Thus, when dealing with the effect of radiation on the total number of females, the highest significant mean comes to be in the 8 m. height, followed by 6 m. On analysing the constituents of this item, i.e., the numbers of living and dead females, it appears that in the case of living females the highest number is at 8 m., whereas in case of dead females the reverse is true, the highest number being at 6 m. Although the survival percentage of females is low at

TABLE III

November-December count. Result of analysis of data in the shady tree, heights and directions arranged according to magnitude of population. Inseparable means are put between brackets. The difference in those marked with an asterisk is significant at 10% level.

Items	Heights in metres (8-6-7-5)	Directions in symbols
Total pupulation	(8–6–7–5) – (4–3)	(SW)-(C)-(W-E-SE-N-NW-S-NE)
Total No. of nymphs	(8–6–7–5) – (4–3)	SW-C-(W-E-SE-N-NW-S-NE)
No. of dead nymphs.....	(6–7–8–5) – (4–3)	SW-(C-W)-(E-SE-N-NW-S-NE)
No. of living nymphs	(8–5–6–7) – (4-3)	(C-SW-E-SE-N-W-NE-S-NW)
Total No. of adults.....	8–(6–7–5) – (3–4)	(C-SW-E-SE-W-N-NW-S-NE)
No. of dead adults	(8–6–7–5) – (3–4)	(W-SW-C-SE-NW-E-N-S-NE)
Total No. of females	8–6–7– (5–3–4)	(SW-W-C-E-SE-NW-N-S-NE)
No. of living females	8–(7–6–5–3–4)	insignificant
No. of living ovi-females	6–(5–7–8–3–4)	insignificant
No. of dead females	6–(8–7–5) – (3)–(4)	W–(SW–C–NW–SE–E–N–NE–S)
Total No. of males	8–(6–7–5) – (3–4)	C–(E–SE–SW–W–N–S–NW–NE)
No. of living males	8 – (6–7–5) – (3–4)	C-(E-SE-SW-W-N-S-NW-NE)
No. of dead males	(8–6–7–5) – (3–4)	(W-C-SE-SW-N-E-S-NW-NE)
Perc. surv. of nymphs	(8–5–6–7–4–3)*	insignificant
Perc. surv. of females	8 – (4–7–5–6) – 3	(E-SE-S-SW-C-NE-N-W-NW)

all heights, averaging 33.6%, yet the highest percentage (55.2%) is at 8 m., while the lowest (11.6%) is at 3 m. The same applies to the total number of nymphs. It is highest at 8m., and the number of living nymphs is also highest at 8 m., while the number of dead nymphs is highest at 6 m. Inspite of the survival percentage of nymphs (averaging 19.2%) being only significantly different at the level of P 10%, yet there is a clear gradation in magnitude from up downwards; the highest percentage (24.1%) being at 8 m. height, and the lowest (12.5%) at 3 m. height.

In case of the number of living ovipositing females, it was found that the numbers were divisible into two groups, namely 6 m. and (5-7-8-3-4), in spite of the fact that the highest number of living females in general was at 8 m. height. The increased number of ovipositing females at 6 m., may be attributed to earlier sexual maturation and oviposition at the upper exposed parts of the tree which resulted in minimizing the number of ovipositing females at higher levels at the time of counting.

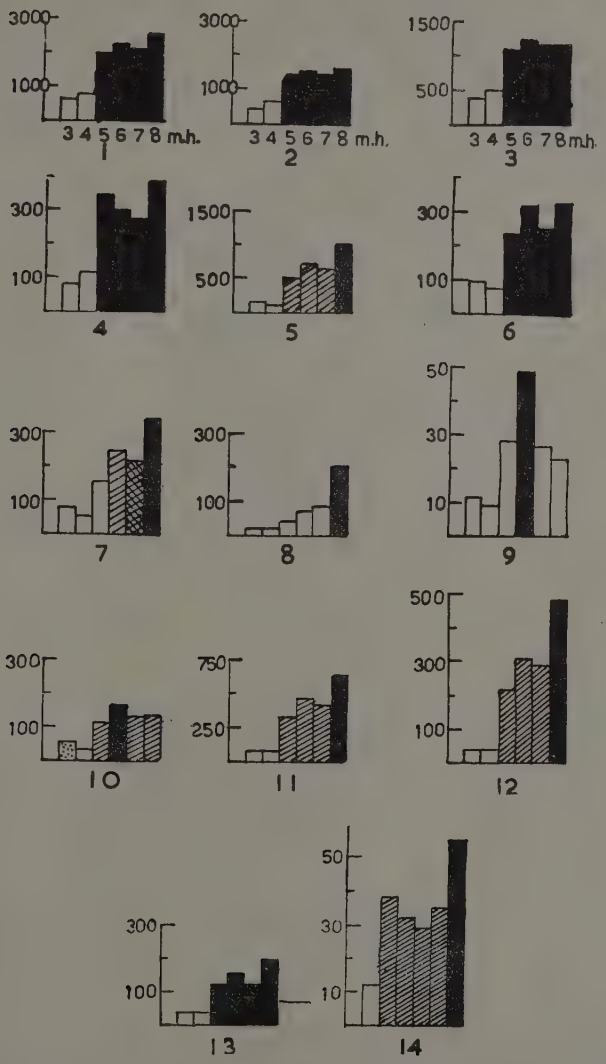

FIG. 4 : November-December count, shady tree. Mean number of insects per 10 leaves in different heights. Inseperable means are given the same shade : (1) total population, (2) total number of nymphs, (3) number of dead nymphs, (4) number of living nymphs, (5) total number of adults, (6) number of dead adults, (7) total number of females, (8) number of living females, (9) number of living ovipositing females, (10) number of dead females, (11) total number of males, (12) number of living males, (13) number of dead males, (14) percentage survivors of females.

With regard to directions it shouid be noted that during that season the duration of exposure to sun rays is longer in the southern hemisphere of the tree than in its northern hemisphere. Although the central core of the tree was taken as a separate direction in the analysis of variance, yet it should be noticed that it was more affected by heights since it is nearly uniformly affected by weather conditions from all directions. Thus, if the symbol denoting the central mean of any item

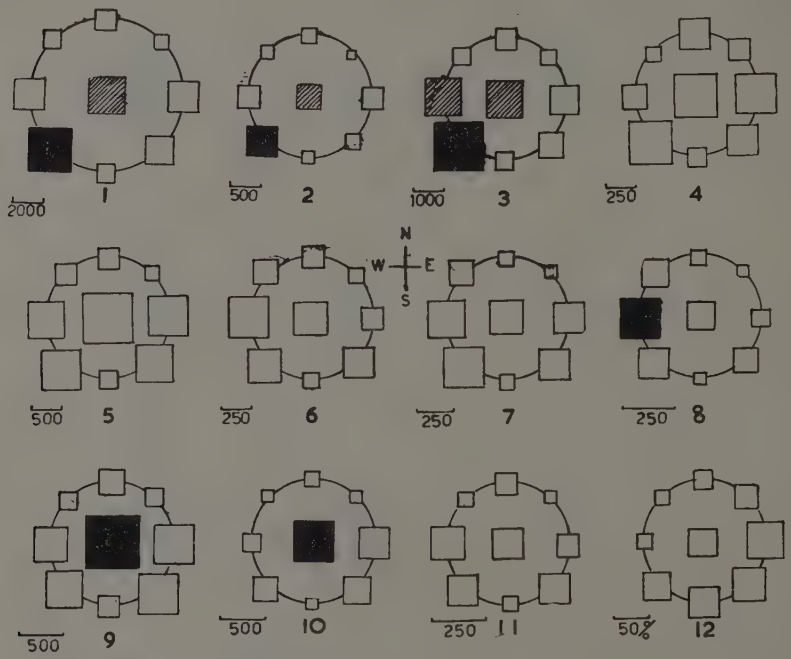

FIG. 5 : November-December count, shady tree. Mean number of insects per 10 leaves in different directions. Inseparable means are given the same shade: (1) total population, (2) total number of nymphs, (3) number of dead nymphs, (4) number of living nymphs, (5) total number of adults, (6) number of dead adults, (7) total number of females, (8) number of dead females, (9) total number of males, (10) number of living males, (11) number of dead males, (12) percentage survivors of females.

in Table III — whether it stood as a significantly separable group or incorporated with certain directions in an inseparable group — was excluded, it can be observed that there is always a tendency for the highest population to occur in the SW or W directions of the tree and the least population in the NE or NW.

In the case of the total population, the means of directions were divisible into two statistically different groups, namely SW and (W-E-SE-N-NW-S-NE).

Thus, the highest population occurred in the SW direction of the tree followed by a group comprising 7 directions the means of which are inseparable. And, as the symbols are arranged in order of magnitude, it can be observed that the highest population occurred in the SW is follwed by that in the W and E; thus, giving the impression that the highest population is the southern hemisphere of this tree which is generally longer exposed to sun rays (Fig. 5 (1)). But the S direction harboured a very low mean, and this unexpected result may be due to the fact that the tree was closely shaded by an adjacent tree lying southwards and the leaves were more or less kept away from sun rays. Figure 6 is a representation of the total population on ten leaves taken from the different directions at each height. The appreciable

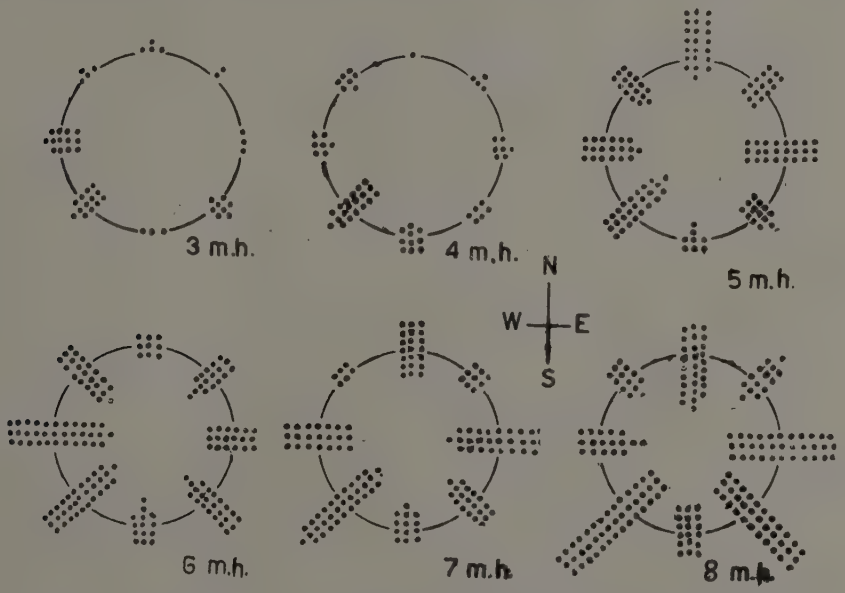

FIG. 6 : Total population per ten leaves taken from different direction at each height, • = 100 insects.

effect of height on the population is well noted, but with regard to directions it can be observed that at all heights the highest population occurred at the SW except at 6 m. height where it was at the W followed by the SW. Moreover, it can be observed that at each height the southern hemisphere of the tree tended to harbour more insects than the northern hemisphere. Furthermore, the population in the S direction was unexpectedly low at each height.

In the November-December count, the nymphs formed 69.2% of the total population, and the means followed the same order of magnitude. The means of

dead nymphs were divisible into three separable groups, namely, SW, W and (E-SE-N-NW-S-NE), i.e., the highest population was in the SW and the lowest in the NE. The mean in the W was statistically different from both that in the SW and in the E the difference between the percentages of survivors in nymphs, however, is insignificant, the mean of 54 counts was 19.2%, ranging between 0 and 40.9%. This means that weather conditions exerted a high percentage of natural mortality which did not vary statistically throughout the different parts of the tree. It is natural, therefore, to find out that the means of the numbers of dead nymphs have followed the same order of magnitude shown in the total number of nymphs and, to a great extent, the succession shown in the total population with a slight difference in grouping as nymphs were a demonating component. The difference between the means of living nymphs was significant, but they all formed one inseparable group. The highest number occurred in the SW but the succession of other directions was different to what was shown in the previous item. Although SW was followed by E the difference between the latter and SE, N., W and NE was insignificant. It can be observed from Figure 5 (4), that the population of living nymphs was much higher in the southern hemisphere of the tree than in the northern one. The difference between E and S or NW is significant, but between S and NW is insignificant. This is in agreement with the above mentioned observation that the S direction always contained a lower population.

Similarly, the difference between the means of total adults, dead adults, total females, dead males and percentage of survivors among females was significant; but means were inseraprable into groups. There was no significant difference between the means of both living females and living-ovipositing females.

The males, total, living and dead, were almost concentrated in the southern hemisphere of the tree. The means of all directions were statistically different but not separable into groups. In total males there was no significant difference between E, SE, SW, W and N; but the difference was significant between S and E or SE — between NW and E, SE and SW — between NE and E, SE and SW. The succession of means of living males is practically the same and although the L.S.D did not separate between the first four directions, i.e, E, SE, SW and W, yet it could separate between E and each of N, S, NW and NE. It could also separate between NE and SE. The highest mean of dead males occurred in the W and the difference between the successive means: W, SE, SW, N and E was not significant. But still the L.S.D. could separate between these and other directions.

For the percentages of survivors of females the means were statistically different, the highest occurring in the E while the lowest in NW. Again, the highest successive directions : E, SE, S, SW and NE were insignificantly different from each other, but the L.S.D. could separate some other directions. There was no significant difference between the means of percentage survivors of nymphs, but similar to what was found in the percentage of survivors of females the highest mean occurred in the E followed by SE and the lowest in NW preceded by W.

2. March-April count

a. Sunny tree

March-April marks a period of moderate temperature and lower humidity (Fig. 1). The sun rays are making an angle of 45° and the leaves are more affected during this period by the heat caused by radiation than in the previous count. The southern hemisphere of an exposed tree is still directly exposed to sun rays and leaves in the northern hemisphere are more or less shaded. This resulted in a certain distribution summarized in Table IV. When this is compared with that shown in Table II

TABLE IV

March-April count. Result of analysis of data (—, difference between means is insignificant; +, result is significant at P level of 5%; ++, result is significant at P level of 1%).
The difference in those marked with an asterisk is significant at 10% level.

Items	Heights		Directions	
	Sunny	Shady	Sunny	Shady
Total population	++	++	*	+
Total number of nymphs	++	++	—	+
No. of dead nymphs.....	++	++	—	*
No. of living nymphs	++	++	—	—
Total No. of adults.....	—	++	+	—
No. of dead adults	—	++	—	—
Total No. of females	—	++	—	—
No. of living females	+	++	++	—
No. of living ovi-females ...	++	++	*	—
No. of dead females	—	—	—	—
Total No. of males	—	++	—	+
No. of living males	—	+	—	—
No. of dead males	—	++	++	++
Perc. surv. of nymphs	—	++	—	—
Perc. surv. of females	—	—	—	—
No. of parasitized insects ..	*	++	—	—

with regard to the sunny tree two outstanding features can be noted. Firstly, the means of more items are statistically different and secondly, the level of significance is very much higher. In the shady tree nearly all tems of the population are very much affected by heights, and the means are different at a very high level of probability, whereas a very few items are affected by directions and the level of significance is low.

In the sunny tree the population tended to be more concentrated in the uppermost part of the tree. This is the part more exposed to sun rays where heat had an accumulative effect during this count and the preceding period and resulted in

giving the insect a more favourable habitat. The means of total pupulation were divisible into three separable groups, the highest population was at 8 m. height fol-

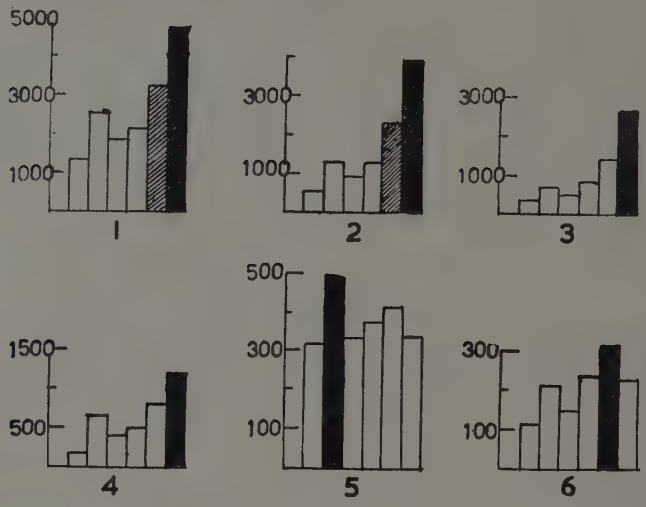

FIG. 7 : March-April count, sunny tree. Mean number of insects per 10 leaves in different heights. Inseparable means are given the same shade : (1) total population, (2) total number of nymphs, (3) number of dead nymphs, (4) number of living nymphs, (5) number of living females, (6) number of living ovipositing females.

TABLE V

March-April count (sunny tree), heights and directions arranged according to magnitude of population. Result of analysis of data. Inseparable means are put between brackets. The difference in those marked with an asterisk is significant at 10% level. Difference between means of other items is insignificant.

Items	Heights in metres	Directions in symbols
Total population	8–7– (4–6–5–3)	SE - (W-N-C-NE-E-SW-S-NW)*
Total No. of nymphs	8–7– (4–6–5–3)	insignificant
No. of dead nymphs	8–7– (6–4–5–3)	insignificant
No. of living nymphs	8– (7–4–6–5–3)	insignificant
Total No. of adults.....	insignificant	(SE-N-NE-E-C-W-SW-NW-S)
No. of living females	4– (7–6–8–5–3)	(N-SE-NE-W-C-E-SW-NW-S)
No. of living ovi-females	7– (6–8–4–5–3)	SE - (E-SW-W-C-N-NE-S-NW)*
No. of parasitized insects	(7–4–5–8–6–3)*	insignificant

lowed by that at 7 m., (Table V and Fig. 7). The lowest population occurred at 3 m.; but the means at 4, 6, 5, and 3m., were not significantly different. With regard to

directions means were significantly different at 10% level, the highest mean was at SE and the lowest at NW and means fell in two separable groups.

Nymphs formed the majority of the total population (64.8%) and the highest mean also occurred at 8 m., the lowest at 3 m. On the other hand the means for adults — which formed 35.2% of the population — were insignificantly different. In other words, the number of nymphs per leaf increased significantly from down upwards irrespective of directions (result was insignificant), whereas the sum total

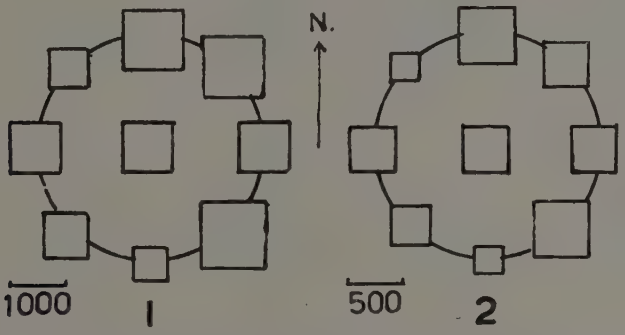

FIG. 8 : March-April count, sunny tree. Mean number of insects per 10 leaves in different directions. Inseparable means are given the same shade. 1, total number of adults; 2, number of living females.

of adults was more or less uniform with regard to heights but higher in SE than in any other direction (Fig. 8 (1). Although the means in the different directions were inseparable into groups, yet there was no significant difference between SE, N, NE, E and W, but the difference was significant between SE and the other three directions, and between N and NE.

The percentage of survivors among nymphs was 35.0%. This was the average of 54 counts, and the analysis showed that the percentages, though ranging between 52 and 62.9, were insignificantly different with regard to both heights and directions. But the means of numbers of both dead and living nymphs, were statistically different with regard to heights. The highest mean occurred at 8 m., and the lowest at 3 m. height with a slight difference as regards grouping.

The means for the total number of females were insignificantly different with regard to heights and directions. But both living and living-ovipositing females, which formed together the majority of the total number of females (56.9%), were affected by heights. In living females, the highest significantly different mean occurred at 4 m. height followed by a group comprising all other heights. This is in agreement with the succession of means for the total number of adults which though insignificantly different but showed an approximate order of magnitude : 4-7-5-8-6-3. It is possible to deduce that conditions at any height or direction harbouring the

peak of total population were naturally most favourable to the growth of population and development. Therefore, the presence of the highest mean of living females at 4 m. height would show, by no means, that conditions at this low level were most favourable for development. But, it was the retardation of development at 4 m. height that caused the apparent increase of living females at this height and during this period. Living females decreased upwards as a result of increased rate of development and reaching the end of adult life earlier than at any other height and decreased again downwards as a result of the relatively unfavourable conditions of development retarding maturity and growth of population. The moderate approach of adult condition at 4 m., together with the increased mortality of nymphs at the upper most part of the tree give the impression that the population was starting to change the nature of distribution and beginning to accumulate in the lower part of the tree. The July-August count confirmed this prediction. With regard to directions, the highest mean of living females though occurred in the N, there was no significant difference between N, SE, NE and W. But the difference was significant between them and other directions. In other words there was a tendency for living females to start to accumulate in the eastern hemisphere of the tree. This became much more evident in the July-August count.

Oviposition was dominant at a higher level, the mean of living-ovipositing females was significantly the highest at 7 m. height. This mean formed a separable group and was followed by a group of five heights (6-8-4-5-3) the means of which were statistically insignificant. The lowest significantly different mean occurred at 3 m. height. This showed that though the number of living females was significantly the highest at 4 m. height, yet the development at this period was retarded at that height as previously stated. More females were ovipositing at 7 m., than at any other height. A glance at Table V would show that the mean of any item at 7 m. height stands the second in order of magnitude. The tremendous number of nymphs at 8 m. height, evidently the outcome of earlier sexual maturity and oviposition of females at this height, had over-shadowed the number of ovipositing females. On the other hand the number of ovipositing females was over-shadowed by the still younger females dominating at 4 m. height. As far as directions are concerned there was a significant difference between means of living ovipositing females at 10% significance level; the highest mean occurred at SE and the lowest at NW, resembling the succession of means in the total population to a great extent.

b. Shady tree

The occurrence of the highest population at the upper most zone of the shady tree was also met with in March-April count (Table VI and Fig. 9). The highest mean at 8 m. height formed either a significantly separable group or included with means of other heights in an inseparable group. The lowest mean occurred at 3 m. height and it either formed a separate group significantly different from that at 4 m. or included with it in an inseparable group. A few items were influenced by directions,

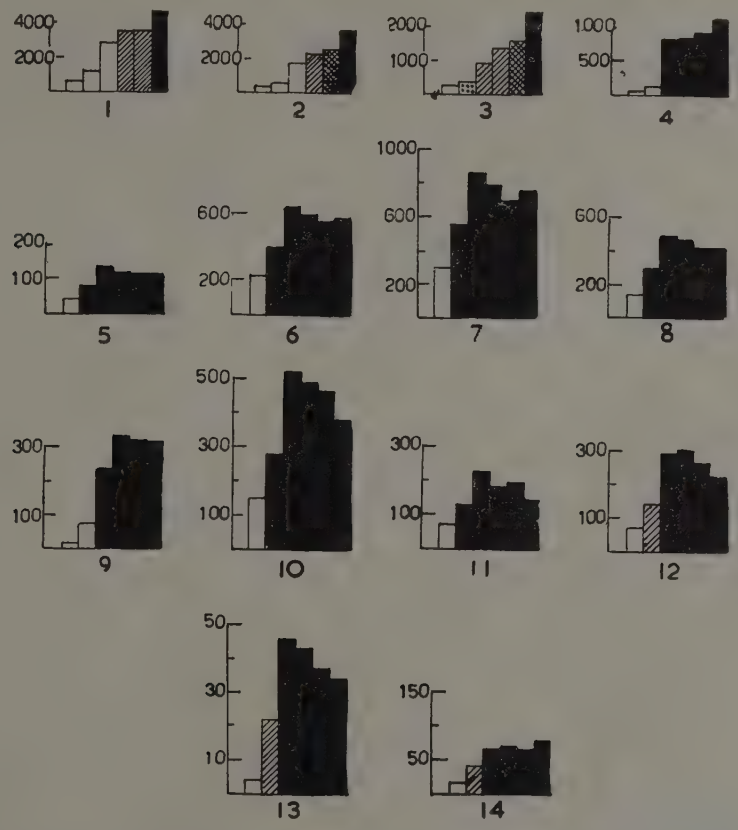

FIG. 9 : March-April count, shady tree. Mean number of insects per 10 leaves in different heights. Inseparable means are given the same shade : (1) total population, (2) total number of nymphs. (3) number of dead nymphs, (4) number of living nymphs, (5) total number of adults, (6) number of dead adults, (7) total number of females, (8) number of living females, (9) number of living ovipositing females, (10) total number of males, (11) number of living males, (12) number of dead males, (13) percentage survivors of nymphs, (14) number of parasitized insects.

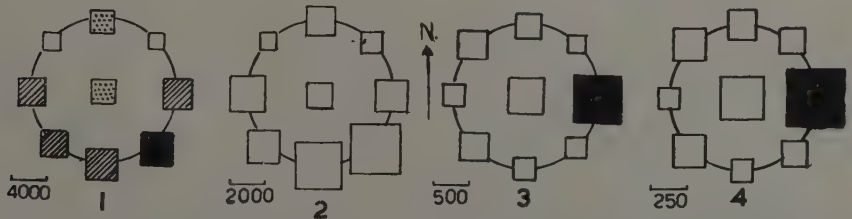

FIG. 10 : March-April count, shady tree. Mean number of insects per 10 leaves in different directions. Inseparable means are given the same shade : (1) total population, (2) total number of nymphs, (3) total number of males, (4) number of dead males.

namely, total population, total number of nymphs, total number of males and dead males with the highest mean in SE or E and the lowest at NE or NW. The means of dead nymphs were significantly different at 10% level.

TABLE VI

Mard-April count (shady tree), heights and directions arranged according to magnitude of population Result of analysis of data. Inseparable means are put between brackets. The difference in those marked with an asterisk is significant at 10% level.

Items	Heights in metres	Directions in symbols
Total population	8– (7–6) –5–4–3	SE - (S-E-W-SW) - (N-C)-(NW-NE)
Total No. of nymphs	8–7–6– (5–4–3)	(SE–S–W–E–SW–N–C–NE–NW)
No. of dead nymphs	8–7– (6–5) –4–3	(SE-S-W-E-SW-N-C-NE-NW)*
No. of living nymphs	(8–6–7–5) – (4–3)	insignificant
Total No. of adults.....	(5–6–7–8–4) –3	insignificant
No. of dead adults	(5–6–8–7–4) –3	insignificant
Total No. of females	(5–6–8–7–4) –3	insignificant
No. of living females	(5–6–7–8–4) –3	insignificant
No. of living ovi-females	(6–7–8–5) - (4–3)	insignificant
No. of dead females	insignificant	insignificant
Total No. of males	(5–6–7–8–4) –3	E - (C-NW-SW-N-SE-W-S-NE)
No. of living males	(5–7–6–8–4) –3	insignificant
No. of dead males	(6–5–7–8) –4–3	E - (C-NW-SW-N-SE-NE-W-S)
Perc. surv. of nymphs	(5–6–7–8) –4–3	insignificant
Perc. surv. of females	insignificant	insignificant
No. of parasitized insects	(8–6–5–7) –4–3	insignificant

The means for the total population, total number of nymphs and dead nymphs are in regular succession from up downwards. In total population the means for 7 and 6 m. height formed one separable group. With regard to directions it can be observed that the means were divisible into 4 separable groups, but the southern hemisphere of the tree harboured most of the population (Fig. 10 (1). The highest significantly different mean was at SE followed by S, while in November-December count the highest mean occurred in SW followed by W. Then, it is apparent that the distribution of the total population, though stable in both counts with regard to heights its peak seemed to shift from SW to SE in March-April. Had the apparent change in the position of the sun in the different seasons any appreciable effect on the distribution of the population with regard to directions the condition in the sunny tree, freely exposed from all directions, would have been different. But the means for the total population did not show a highly significant difference in November-December, March-April and July-August counts (Tables II, IV, VII). The answer for the deviation of the peak of the population in the shady tree from SW to SE must, therefore, lies with the extension of shade exerted on this particular tree by the adjacent ones.

The majority of the population were nymphs, they formed 63.4% of the

total population. There was a close similarity between the gradiant of means in both the total population and nymphs with regard to heights and directions. The difference was in grouping, the means of heights were divisible into four groups, whereas the means of directions though significantly different fell in one group. The difference between SE, S, W, E, SW and N was insignificant; but was significant between them and other directions.

The percentage of survivors among nymphs was low, the average of 54 counts was 31.2%. Consequently, the means for dead nymphs followed the same order of magnitude with a slight difference in grouping. The means for total nymphs were divisible into four separable groups, but for dead nymphs they fell into five groups. The means for the relatively smaller number of living nymphs were divisible into two groups and the gradient was nearly the same as the difference between means of any group was insignificant. It can be observed, therefore, that the tremendous number of nymphs found in the upper most zones of the tree were merely responsible for the distribution of the total population. A glance at the succession of means for the total adult population or any of its components would show that the highest significantly different mean occurred almost always in the middle of the tree, at 5 or 6 m. height, decreasing upwards and downwards (Fig. 9 (5-12)). Again, it was the difference of the microclimate at different heights that caused such distribution. In the middle of the tree there were apparently moderate conditions of development, and this was shown by the dominance of adults and moderate numbers of nymphs. The extremes occurred at the top and bottom parts of the tree, at 8 and 3 m. heights, respectively. At the former development was accelerated, this was shown by the dominance of nymphs; at 3 m. development was retarded, and this was shown by the minimum numbers of adults. It has to be noted that this height harboured in general the lowest mean of the population.

The means for other items of the adult population showed either the same or an approximate succession of magnitude (Table VI). But directions seemed to play an unimportant part in the distribution of adult population. It was only in the total number of males and dead males that directions exerted an influence. The highest significantly different mean occurred in E and the means in the other group were insignificantly different. This is an approximate approach to the orientation of the total population. In Novebmer - December count, directions exerted a similar effect on the orientation of total males as the highest significantly different mean occurred in E., but the highest mean for dead males was in W.

The highest percentage of survivors among nymphs occurred at 5 m. height decreasing upwards and downwards. At the middle of the tree insects may be protected from the effect of wind which was mainly the cause of death at higher exposed zones. The percentage of survivors among nymphs was generally lower than it was among females. The result of 54 counts gave 31.2 and 57.3% survivors among nymphs and females, respectively. The means of percentages of survivors among females were affected by neither heights nor directions.

The number of parasitized insects was very low among this population. The female was almost always the stage parasitized, and the mean percentage of parasitism was 8.71 and 8.95 in the shady and sunny tree, respectively. This was the result of examining 35,756 females in the shady tree and 36,813 in the sunny tree. The means for parasitized insects in the sunny tree did not differ statistically at 5% level, but at 10% level there was an appreciable difference between means at different heights. They were arranged as follows according to order of magnitude (7-4-5-8-6-3) (Table V). In the shady tree they did not differ statistically between 8 and 5 m. height, they formed one inseparable group significantly different from the mean at 4 and 3 m. height. Means were insignificantly different with regard to directions.

3. July-August count

When dealing with this count two facts should be taken into consideration. The first is that the sun during this hot season is nearly perpendicular, the angle of inclination of rays being about 80°. The second is the distribution of insects on the trees during the preceding count. The result of the nearly perpendicular rays is clearly

TABLE VII

July-August count. Result of analysis of data (—, difference between means is insignificant; +, result is significant at P level of 5%; ++, result is significant at P level of 1%). The difference in those marked with an asterisk is significant at 10% level.

Items	Heights		Directions	
	Sunny	Shady	Sunny	Shady
Total population	—	++	*	—
Total No. of nymphs	—	++	—	—
No. of dead nymphs	—	++	—	—
No. of living nymphs	—	++	*	—
Total No. of adults	—	*	*	+
No. of dead adults	++	*	—	++
Total No. of females	++	+	—	+
No. of living females	+	++	+	—
No. of living ovi-females	—	++	*	—
No. of dead females	++	+	—	++
Total No. of males	*	—	+	—
No. of living males	*	—	—	—
No. of dead males	*	—	+	+
Perc. surv. of nymphs	++	++	++	+
Perc. surv. of females	++	++	—	—
No. of parasitized insects	+	—	—	—

seen in the negligible effect of directions of the distribution of insects in both the shady and sunny tree as is shown in Table VII. Moreover, it resulted in a clearly significant effect of heights in the shady tree and less so in the sunny tree.

a. Sunny tree

In case of the sunny tree heat is distributed in a peculiar way. Both extremities of the tree receive more heat than the intermediate zone. The upper extremity receives direct sun rays, whereas the lower extremity receives the heat reflected from

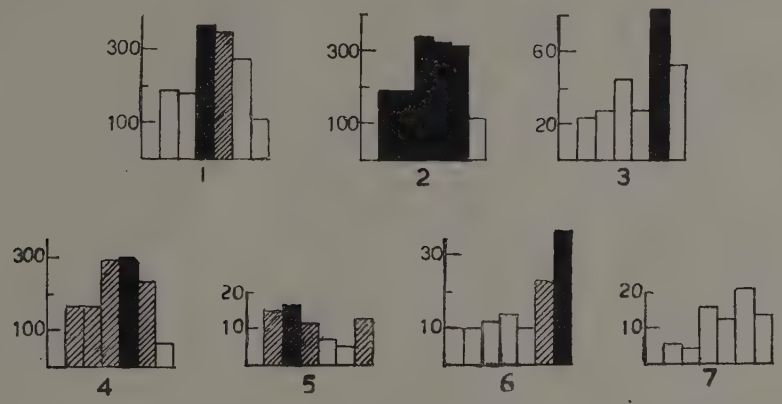

FIG. 11 : July-August count, sunny tree. Mean number of insects per 10 leaves in different heights. Inseparable means are given the same shade : (1) number of dead adults, (2) total number of females, (3) number of living females, (4) number of dead females, (5) percentage survivors of nymphs, (6) percentage survivors of females, (7) number of parasitized insects.

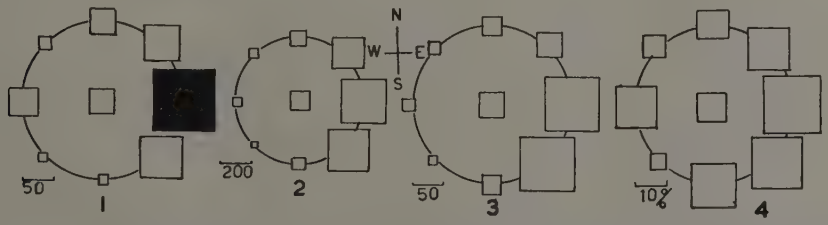

FIG. 12 : July-August count, sunny tree. Mean number of insects per 10 leaves in different directions. Inseparable means are given the same shade : (1) number of living females, (2) total number of males, (3) number of dead males, (4) percentage survivors of nymphs.

the hot unshaded sandy soil below. The result of such gradation will be that the temperature in the middle zone becomes comparatively mild. The effect of such double source of heat, together with the previous distribution of insects in the preceding count caused the total population to be insignificantly affected by heights. However, in case of the few items of population which showed to be significantly affected by height, viz., number of dead adults, total number of females, numbers of both

living and dead females (Table VIII) we find that the highest population fluctuated between 5 and 7 m., or in other words in the intermediate zone. The lowest population was either at 8 or 3 m. height. In the percentage of survivors among nymphs and females means were arranged in a peculiar way, giving an almost a different result. It is known that shells of dead nymphs and females are retained for a very long time and not even fall off dropped leaves until they get dry. Moreover, natural mortality may occur among females when oviposition comes to an end or during oviposition as a result of climatic condition or parasitisim. Therefore, the percentage of dead nymphs and females can, by no means, give a true picture of the distribution of

TABLE VIII

July-August count (sunny tree), heights and directions arranged according to magnitude of population. Result of analysis of data. Inseparable means are put between brackets. The difference in those marked with an asterisk is significant at 10% level. Difference between means of other items is insignificant.

Items	Heights in metres	Directions in symbols
Total population	insignificant	E-SE - (N-C-NE-W-S-NW) - SW*
No. of living nymphs	insignificant	E-SE - (W-NE-N-S-C) - NW-SW*
Total No. of adults.....	insignificant	E-SE - (NE-C-N-W-S-NW) - SW*
No. of dead adults	5–6– (7–3–4–8)	insignificant
Total No. of females	(5–6–7–3–4) –8	insignificant
No. of living females	7–(8–5–6–4–3)	E - (SE-NE-W-C-N-NWS-W)
No. of living ovi-females	insignificant	E-W-N · (C-SE-NE-NW-S-SW)*
No. of dead females	6– (5-7-3–4) 8	insignificant
Total No. of males	8–(5–7–6–3–4)*	(E-SE-NE-C-N-S-W-NW-SW)
No. of living males	8–(7–5–6–3–4)*	insignificant
No. of dead males	5–(6–8–7)–4–3*	(SE-E-NE-C-S-N-W-NW-SW)
Perc. surv. of nymphs	4–(3–8–5)–6–7	(E-SE-S-NE-W-C-N-NW-SW)
Perc. surv. of females	8–7–(5–4–6–3)	insignificant
No. of parasitized insects ...	(7–5–8–6–3–4)	insignificant

favourable and unfavourable zones for the growth of the population. Such a true picture could be better obtained from the totals rather than the percentage of the components. The number of parasitized insects was highest at 7 m. and lowest at 4 m. height.

Four items were affected by directions at 1 and 5% level, viz., number of living females, total number of males, number of dead males and the percentage survival of nymphs. The E direction followed by the SE, harboured most of the population and the lowest population was in the SW. Thus, the gradation in case of the living females was E-(SE-NE-W-N-NW-S-SW). Even in cases where all directions formed one inseparable group, the gradation nearly followed the same trend. Thus in case of percentage survivors of nymphs, for example, the grada-

tion was (E-SE-S-NE-W-N-NW-SW). It is only in the case of number of dead males that the SE direction preceded the E direction. The difference between four other items was significant at 10% level, viz., total population, number of living nymphs, total number of adults and number of living ovipositing females. Means followed a similar order of magnitude, the highest numbers were at E and the lowest at SW.

b. Shady tree

In case of the shady tree the top of the tree receives direct sun rays and the heat produced is rather detrimental to the insects. The lower parts of the tree, on the other hand, are the most shaded and thus no direct sun rays can reach the soil below. The temperature gradient is decreasing from above downwards resulting in the total population being highest at the mild temperature of the lowest height and lowest at the top, with nearly uniformly increasing number inbetween. The groups of heights (Table IX) are (3-5-4-7-6) and 8 m. height. Although the first 5 heights

TABLE IX

July-August count (shady tree), heights and directions arranged according to magnitude of population. Result of analysis of data. Inseparable means are put between brackets. The difference in those marked with an asterisk is significant at 10% level. Difference between means of other items is insignificant.

Items	Heights in metres	Directions in symbols
Total population	(3–5–4–7–6) –8	insignificant
Total No. of nymphs	3– (4–5–7–6–8)	insignificant
No. of dead nymphs.....	3– (5–4–7–6–8)	insignificant
No. of living nymphs	(3–4–5) – (7–6–8)	insignificant
Total No. of adults.....	(7–5–3–6–4) –8*	SW–(W–N–C–S–NE–NW–E–SE)
No. of dead adults	7–(5–6–3–4) –8*	SW–(W-N-C-NE-S-NW-E-SE)
Total No. of females	(7–5–3–4–6) –8	SW-(W-N-C-NE-S-NW-E-SE)
No. of living females	(3–4–5–6–7) –8	insignificant
No. of living ovi-females	(3–4) – (5–7–8–6)	insignificant
No. of dead females	(7–5–3–6–4) –8	SW–(W–N–NE–C–S–NW–E–SE)
No. of dead males	insignificant	SW-(W-E-C-NW-S-N-NE-SE)
Perc. surv. of nymphs	(4–3–5) – (8–6–7)	(E-NE-NW-C-N-S-SE-W-SW)
Perc. surv. of females	(3–4–6–5) –7–8	insignificant

from an inseparable group, yet the gradation of the increase of population is clear to be from down upwards. This is even more clear in the case of the total number of nymphs, where the lowest height, 3 m., forms a significantly separate group. Those nymphs are supposed to be the younger stages of the progeny of that hot season, and thus seek the most favourable zone of the tree. The living nymphs fall

in two groups; the lower zone (3-4-5) harbours more living nymphs than the upper zone (7-6-8). The increase of number of dead nymphs in the 3 m. height is not due to adverse conditions, but to the fact that the largest number of nymphs is present

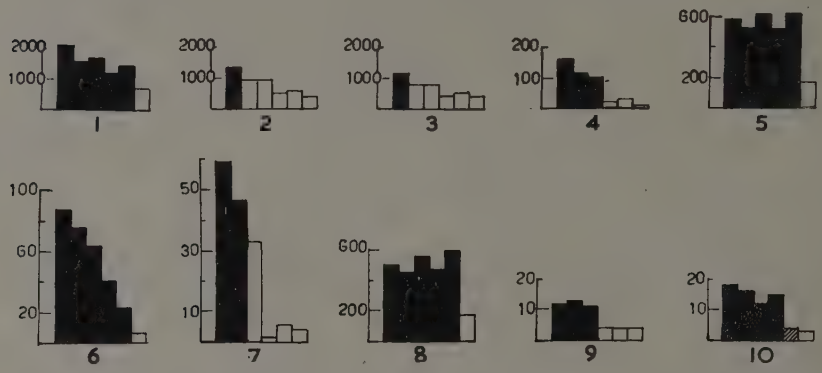

FIG. 13 : July-August count, shady tree. Mean number of insects per 10 leaves in different heights. Inseparable means are given the same shade : (1) total population, (2) total number of nymphs, (3) number of dead nymphs, (4) number of living nymphs, (5) total number of females, (6) number of living females, (7) number of living ovipositing females, (8) number of dead females, (9) percentage survivors of nymphs, (10) percentage survivors of females.

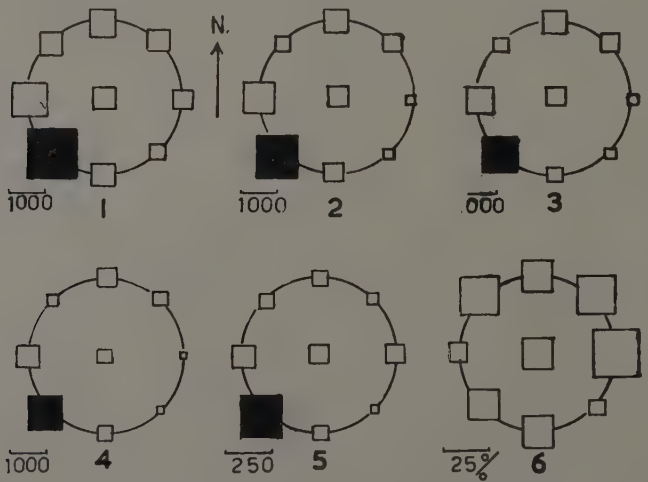

FIG. 14 : July-August count, shady tree. Mean number of insects per 10 leaves in different directions. Inseparable means are given the same shade : (1) total number of adults, (2) number of dead adults, (3) total number of females, (4) number of dead females, (5) number of dead males, (6) percentage survivors of nymphs.

at that height. This could be made more clear when dealing with the survival percentage of nymphs, where again the higher percentage forms a group (4-3-5) which is significantly different from the zone of (8-6-7) (Fig. 13 (9)).

The number of living females also follows the same gradation. They are even more regular in their distribution, the grouping being (3-4-5-6-7)-8. The same also applies to the number of living ovipositing females where the grouping is (3-4)-(5-7-8-6). The irregular grouping of the number of dead females, i.e., (7-5-3-6-4)-8 is not only affected by the adverse conditions during this season, but is also governed by the previous distribution of females in the preceding season, where they used to dominate in the higher zone of the tree. This previous distribution did not only cause the irregularity of distribution of females but also affected the distribution of the total number of adults and caused it to be significant only at 10% level. The means for dead adults follow a similar distribution. Still, the percentage survivors of females shows a rather regular gradation, the grouping being (3-4-6-5)-7-8.

With regard to directions, the tendency of the affected items was to increase in the SW and gradually decreases towards the E and SE directions. In five affected items, viz., total number of adults, number of dead adults, total number of females number of dead females and number of dead males, the SW direction harboured most of the insects and stood significantly different from all other directions. The other directions formed one inseparable group, within which the highest population was in the W and the lowest in the SE direction, with other directions inbetween. Thus the gradation in the total number of adults was SW-(W-N-S-NE-NW-E-SE), and the same gradation was nearly followed in the other items with very slight deviations.

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A PROBABLE EFFECT OF THE MOONLIGHT ON THE VERTICAL DISTRIBUTION OF DIPTERA

(with 4 Text-Figures and 4 Tables)

by SAMIRA EL-ZIADY, PH. D.,

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The moon has been shown, by several authors, to have a direct effect on some animals being mainly of the marine forms especially the river plankton, various polychaete annelids and a marine fish, the Grunion; but the effect of the moon is directly correlated with tides.

The insects are also affected by the moonlight. It was found by amateur entomologists that insects, particularly moths, were usually caught in fewer numbers when the moon was full, and in far greater numbers when it was new moon. HORA (1927), on the other hand, brought forward some data on the effect of the full moon on the swarming flights of Ephemeridae which were recently confirmed by HARTLAND-ROWE (1955).

When trapping insects by light traps, it was also noticed that the moths and other insects came to the trap in considerably greater numbers when the moon was new and the reverse when the moon was full. This was true with two Pyralid moths in Malaya (PAGDEN, 1932), and also with moths and other insects in England (WILLIAMS, 1936-1940). This last author found that there was a definite periodicity of the moon and that in the new moon the geometric mean catch was two to four times that in the full moon. HOSNY (1955), furthermore, obtained similar results when an ultra-violet light was used.

Considering these results, it was thought that the effect of the moon may probably be an indirect one through reducing the efficiency of the traps used in the above experiments by reducing their light intensity and hence decreasing the numbers of insects attracted. But when using a suction trap, and this did not depend on light for attraction, a similar lunar effect was still obtained (WILLIAMS and SINGH, 1951).

These results, if true, may bring forward the suggestions that the moon affects insects in either one of the following ways :

1. — The moonlight has a direct effect on the active population and may reduce the numbers flying.

2. — It may affect the flying habit of the insects so that they may either be found in shady places, like what occurs in mosquitoes, or the insects may be flying at a higher level than usual, mostly attracted to the moon. This leads to the belief that insect population at higher levels is denser at full moon than at new moon, the reverse at lower levels.

For verifying this last alternative, the following experiment was carried out in 1952 and 1953 at Rothamsted Experimental Station, England, where a suction trap mounted on the top of a tower 30 feet above ground was used. This trap sucked

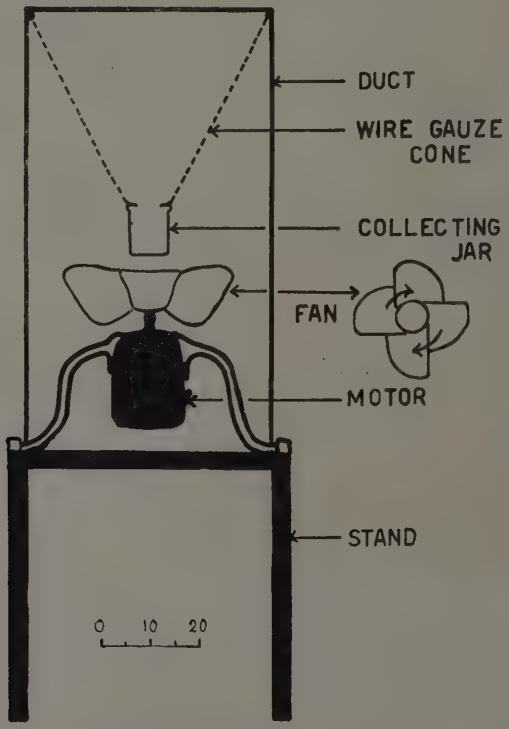

Fig. 1 : A diagrammatic representation of the suction trap.

air by strong electric 18-inch fan mounted at the bottom of a galvanised iron duct and sucked 116.000 cubic feet of air per hour. The insects dropped into a jar near the top of the trap (Fig. 1). This trap was situated in an open field (Fig. 2) and worked

all night, and sampled all active insects flying in the air. Over 90% of these were Diptera, and thus these were only considered in the analysis.

Owing to breakdowns in the trap during the two years, only catches of 9 months could be analysed for the effect of the moon, four in 1952 and five in 1953.

Fig. 2 : A trap within its environment.

The results were expressed as log. (n + 1) and the geometric means were considered in the analysis. The data was corrected to allow for the effect of the night minimum, day maximum temperatures and wind. The lunar month was then divided into four categories of seven days, each with the phase of the moon in the middle, and the mean log. catch (n + 1) of each category was then calculated and was considered in the analysis.

Table I (showing the means of nine lunar months) indicates that out of the nine months analysed, seven (italic figures) showed definite increase of the catch during periods coinciding with, or just before or after full moon, and a marked reduction

TABLE I

Mean log. catch for each phase within a lunar cycle

(mean for 7 days)

Year	Month	F.M.	L.Q.	N.M.	F.Q.	Mean
1952	July	*2.60*	2.71	2.36	2.09	2.44
	August	*1.89*	2.17	1.56	2.15	1.96
	September	*1.71*	1.53	1.66	1.75	1.66
	October	*1.89*	1.24	0.78	1.88	1.45
1953	May	*1.69*	0.83	0.78	1.42	1.18
	June	*1.86*	1.42	1.69	1.88	1.71
	July	2.56	2.40	*2.71*	2.39	2.52
	August	*2.68*	2.36	2.64	2.74	2.61
	September	2.18	2.62	*2.40*	2.25	2.36
Mean		*2.12*	1.12	1.84	2.06	1.99
Antilog. — 1		*131*	82	68	114	

F.M. = full moon; L.Q. = last quarter; N.M. = no moon; F.Q. = first quarter.

in the catch at no moon. The remaining two months had more insects at no moon than at full moon, but these two months occurred in late summer and early autumn, 1953. During these periods, there had been a steady increase in the insect population and hence the catch, due to improving weather conditions. This effect is very difficult to eliminate.

The mean catch per night for the four cycles for the nine months are given in Table II.

TABLE II

	F.M.	L.Q.	N.M.	F.Q.
Mean log. catch per night	*2.12*	1.92	1.84	2.06
Antilog. — 1	*131*	82	68	114

These figures show a regular sequence in the activity of Diptera during the four cycles. The activity rose to a peak at full moon, and gradually declined at new moon when the minimum activity occurred. The other two quarters, i.e. the last and first, were intermediate. The mean number of insects at full moon (131) was almost double that at new moon (68). The difference between the two phases is significant at less than 0.05, as shown in Table III.

TABLE III. — *Analysis of variance*

	d.f.	S.S.	M.S.	S.E.
Months	8	8.85273		
Quarters	3	0.43230		
Error	24	1.94170	0.0809	±0.2844
Total	35	10.90130		

S.E. of mean $= \frac{0.2844}{\sqrt{9}} = \pm 0.0948$

F.M. N.M.
Difference = 2.12 — 1.84 = 0.28
t = 2.090 P = less than 0.05

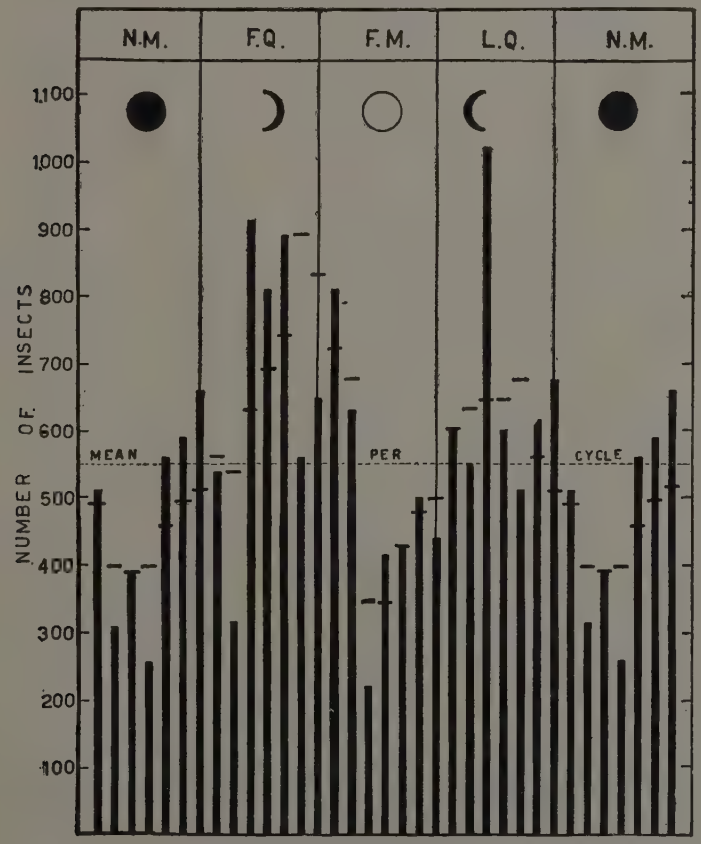

FIG. 3 : Mean number of Diptera (antilog.—1) caught per night in the trap in nine lunar months (F.M., full moon; F.Q., first quarter; L.Q., last quarter; N.M., new moon); broken line (- -), the smoothed 5-day running mean.

This is also illustrated by Figure 3.

The deviations of the four phases from the mean of the corresponding lunar cycle are given in Table IV, and shows that most of the months had positive deviations at full moon and first quarter and negative deviations at no moon and last

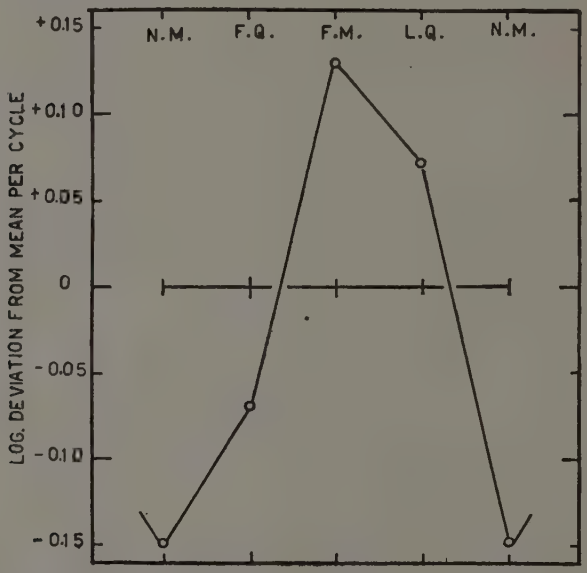

FIG. 4 : Log. deviation of the mean number of Diptera, the corresponding mean number per cycle (lettering as in Figure 3).

quarter. When the means of these departures were plotted the Graph in Figure 4 was obtained, which shows a high positive departure at full moon and a low negative departure at no moon, with the two other phases, i.e. last and first quarters, in between; further emphasizing the increase of insect activitity at full moon and its decrease at new moon.

The results of this experiment give evidence of the probable effect of the moonlight on insect activity. They indicate that at 30 feet above ground level, the peak of activity of Diptera may occur at F.M. rather than at N.M. This was previously noticed by GLICK (1939 and 1942) who used traps attached to aeroplanes and sampled air at 500-50000 feet and found insects, particularly Diptera, most abundant when there was considerable moonlight.

It may then probably be justified to conclude that at 30 feet there is a positive correlation between activity of insects and the moon. Insect population at this level

TABLE IV

Deviations of the four phases from the mean of the corresponding lunar cycle

Year	Month	F.M.	L.Q.	N.M.	F.Q.
1952	July	+ 0.16	+ 0.27	— 0.08	— 0.35
	August	— 0.07	+ 0.21	— 0.40	+ 0.19
	September	+ 0.05	— 0.13	0	+ 0.09
	October	+ 0.44	— 0.21	— 0.67	+ 0.43
1953	May	+ 0.51	— 0.35	— 0.40	+ 0.24
	June	+ 0.15	— 0.29	— 0.02	+ 0.17
	July	+ 0.04	— 0.12	+ 0.19	— 0.13
	August	+ 0.07	— 0.25	+ 0.03	+ 0.13
	September	— 0.18	+ 0.26	+ 0.04	— 0.11
	Total	+ 1.17	— 0.61	— 1.31	+ 0.66
	Mean	+ 0.13	— 0.17	— 0.15	+ 0.07

increases at F.M. and decreases at N.M., the reverse of what occurred at ground level (WILLIAMS, 1936; and 1940, WILLIAMS and SINGH, 1951).

The significance of these findings can be realised when considered in terms of problems of dispersal of insect pests if attracted to the moon. These fly to high levels of the atmosphere and are caught and transported by the wind from one place to another. This point, however, is being tested further on totally different climate and insects, to verify the validity of this phenomenon.

Sincere thanks are due to Dr. C. B. WILLIAMS, for unfailing encouragement and keen interest throughout the course of this study.

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ON THE RELATIVE DISTRIBUTION OF INSECTS AT 5 AND 30 FEET

(with 10 Text-Figures and 1 Table)

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INTRODUCTION

The vertical distribution of different groups of insects and their relative density at various heights and at different times of the year, as far as we are aware, has not yet been considered, especially in a statistical sense.

It was therefore interesting to assess the relative distribution of insects by comparing the ratios between the catches of the different groups obtained at two levels above the ground. The data was obtained from suction traps during a study on the effect of the physical factors on the activity and abundance of insects at 5 and at 30 feet.

This work was carried out for two years, 1952 and 1953, at Rothamsted Experimental Station, Harpenden, England. The results which are presented here are only preliminary and it is hoped that this point will be further extended.

Material and technique

Two large identical suction traps were used in this analysis. The traps were designed by JOHNSON (1947) and each consisted of a powerful electric fan, 18 inch in diameter, fixed at the bottom of a vertical duct of galvanised iron, 3 ft. long and 20 inches in diameter. Suspended from the top and closely fitting to the inside of

the mouth of the duct is a cone of 32-mesh copper wire gauze. Air is sucked in and is filtered through the cone so that the insects drop into a jar at the bottom of the cone. The volume of air sampled is about 116,000 cu. ft. per hour, and is constant except at high wind speeds. The working of the traps was regulated by an electric switch.

One of the traps was mounted on a wooden stand, so that its mouth was nearly 5 ft. from ground level. The other trap was at the top of a tower 30 ft. high. The traps were situated on the lawn west of Rothamsted Lodge and the area around had vegetation which was stable during the two years.

In 1952, the traps were working for two hours during day time, i.e. 12:00 noon to 2:00 p.m., and from half an hour after sunset to half an hour before sunrise. During 1953, however, the night trapping period was shortened to stop at midnight. Greenwich Mean Time was used as Harpenden is very close to 0° longitude.

Weather records of the area were supplied by the Meteorological Station at Rothamsted, situated about 200 yards to the north-west of the traps.

Both traps were changed twice daily, and the catches were sorted into the orders, which included Diptera, Hymenoptera, Coleoptera, Thysanoptera, Hemiptera, Lepidoptera, Collembola, Psocoptera, and Strepsiptera.

The analysis for the day catches were carried out on Diptera, Hymenoptera Coleoptera, Thysanoptera and Aphididae from Hemiptera; and for night catches on Diptera only as these orders dominated the catches and were in enough numbers suitable for such analysis.

RESULTS

Before proceeding to discuss the results, it must be borne in mind that the two years under analysis, i.e. 1952 and 1953, differed from each other in the following points :

1. — *Timing :* In the two years the traps worked during the day time at fixed times from 12:00 noon to 2:00 p.m. without any change. At night, on the other hand, the time of trap operation was changed in 1953, so they worked half night (i.e. from dusk till midnight) instead of the whole night as in 1952.

2. — *Site of the traps :* In the first year the traps were close to a tall tree and they were moved away about 20 yards in the second year because it was thought that the upper trap might have been biased by being close to the tree.

3. — *Breakdowns:* Owing to breakdowns in the traps at different times in both years it was not possible to get as many comparable months as we had hoped.

The first point did not affect the comparison between the day catches of both traps, but it might affect night ratios.

For illustrating the data the monthly mean log. catches of the various orders in the two traps were calculated, for the two years. The corresponding monthly means for the two traps were then plotted against each other on a log. scale. The

horizontal scale is the number in the lower trap, the vertical scale is the number in the upper trap and the diagonals show lines of equal ratios.

Figure 1 shows the relative abundance and the monthly ratios between the two traps, of Diptera caught at night in both years. It will be noticed that in all

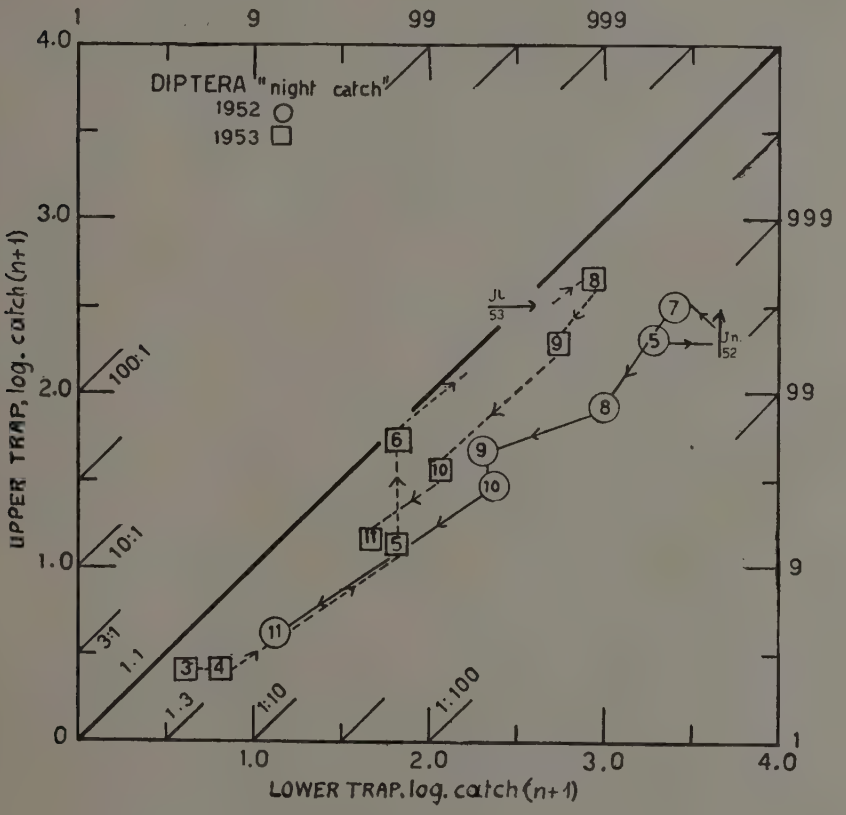

FIG. 1 : Relative distribution of Diptera at night at the two heights 5 ft. and 30 ft. as indicated by the ratios between the two traps. The figures for June 1952 for the upper trap and for July 1953 for the lower trap were not available.

months the lower trap caught more insects than the upper one. The abundance at both heights, with the exception of the abnormally high value in May 1952, tended to move in the same direction in the two years.

It can be generally seen that the mean log. numbers of Diptera increased from low values at the beginning of spring, attained a maximum probably in June 1952 and in August 1953, then decreased again towards November. There was a marked

difference in the two years between monthly ratios. In the first year the ratios obtained between the upper and lower traps were oscillating round 1:10, with the exception of September and November in which the ratios approximated to 1:3. In 1953, on the other hand, the monthly ratios were almost consistently about 1:3 with the exception of March and June which produced even less differences.

This wide variation in the ratios between the Diptera flying at the two heights in both years may lead to several suggestions :

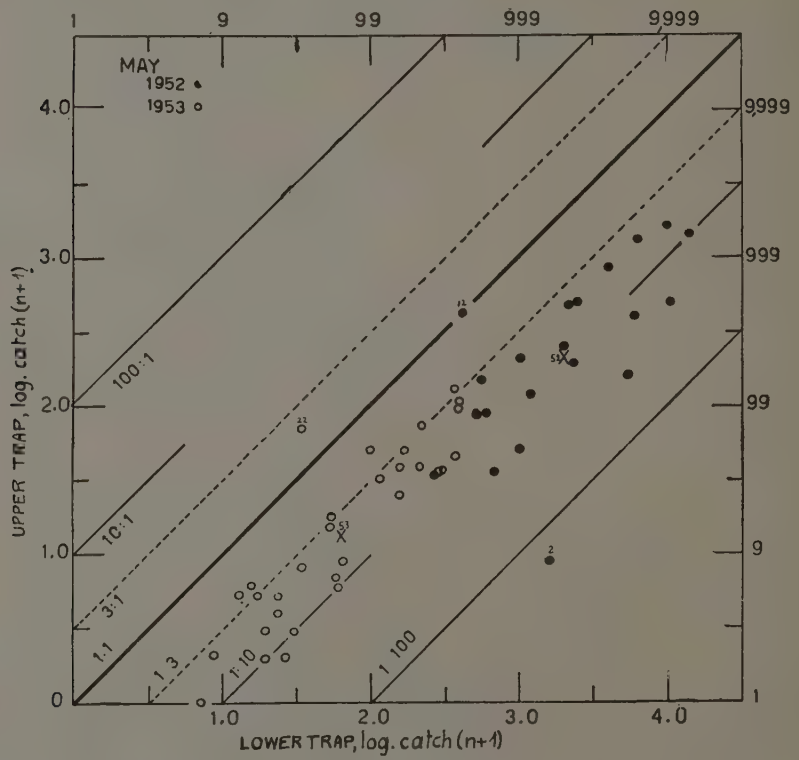

FIG. 2 : Ratios between the log. catch of Diptera per night in the lower and the upper traps in May 1952 and 1953. "X" is the mean log. catch for the month.

(*a*) The differences may be attributed to changing the time of operation of the traps. It is possible that at the upper level Diptera were more active in the first half of the night.

(*b*) If the change of site was responsible it would suggest that there was relatively fewer insects in the upper trap in the first year when it was near the tree, than

in the second year when it was away from the tree. This however is exactly opposite to what we expected, and that before the trap was moved in the open the presence of the tree would increase the number of insects caught.

(*c*) Another possibility is that the species of Diptera which are high fliers tended to be more abundant in the second than in the first year.

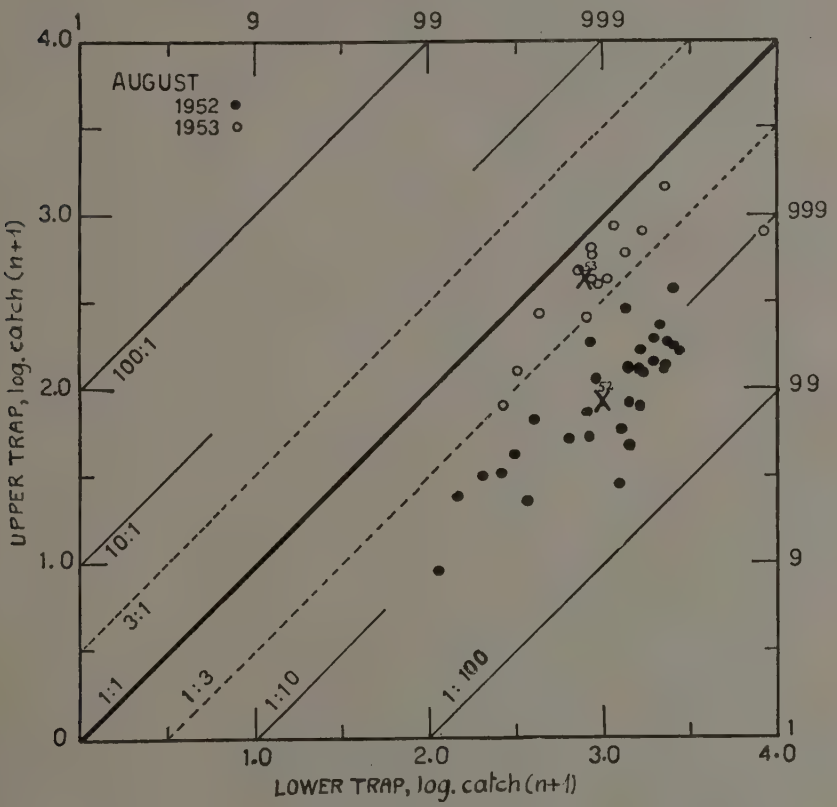

FIG. 3 : Ratios between the log. catch of Diptera per night in the lower and upper traps in August 1952 and 1953.

(*d*) A fourth possible cause is the weather which prevailed during both years. To examine this, the two comparable months in the two years were chosen and the daily log. catches in the two traps were plotted against each other. The months which were available for analysis are May, August, September and October. It is worth noticing that in August of the two years the lower trap caught nearly the same numbers of Diptera, while the upper caught about six times as many in 1953 as in 1952.

Figures 2-5 show these daily ratios between the two traps, and while in August, September and October 1952 the points were very much scattered from their mean monthly values, in 1953 they were more closely congregated round their mean.

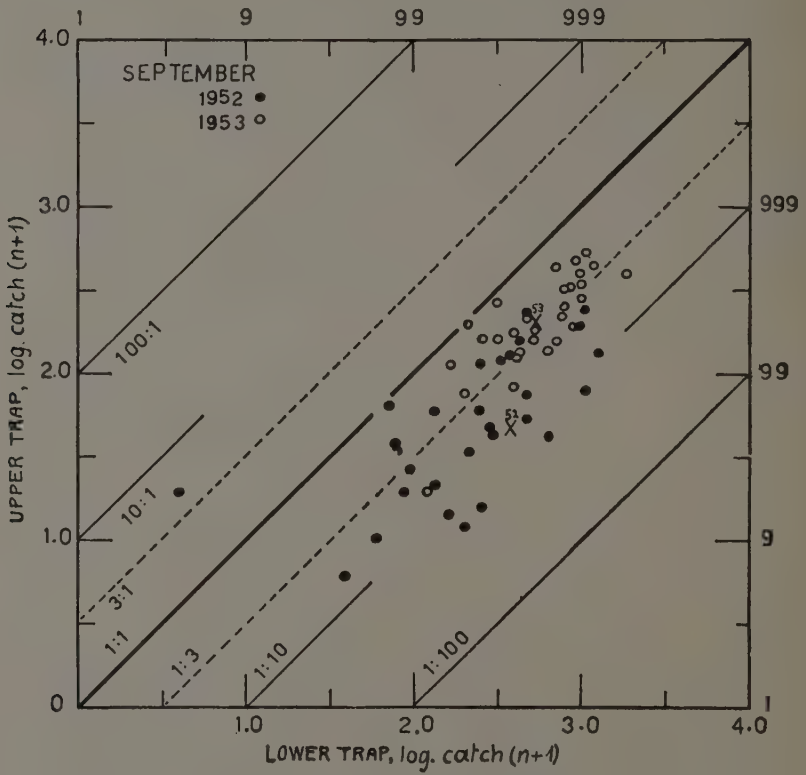

FIG. 4 : Ratios between the log. catch of Diptera per night in the lower and the upper traps in September 1952 and 1953.

In May, on the other hand, the scatter was large in both years and it is obvious from Figure 2 that the daily catches of insects were higher in the two traps in 1952 than in 1953. A closer examination of the night weather prevailed during the four months and given in Table I shows that there was no striking difference in the minimum and maximum temperature and in the wind between the two years to account for this variation. The monthly rainfall, on the other hand, was higher in August, September and October 1952 than it was in 1953 ; in August 2.19 inches

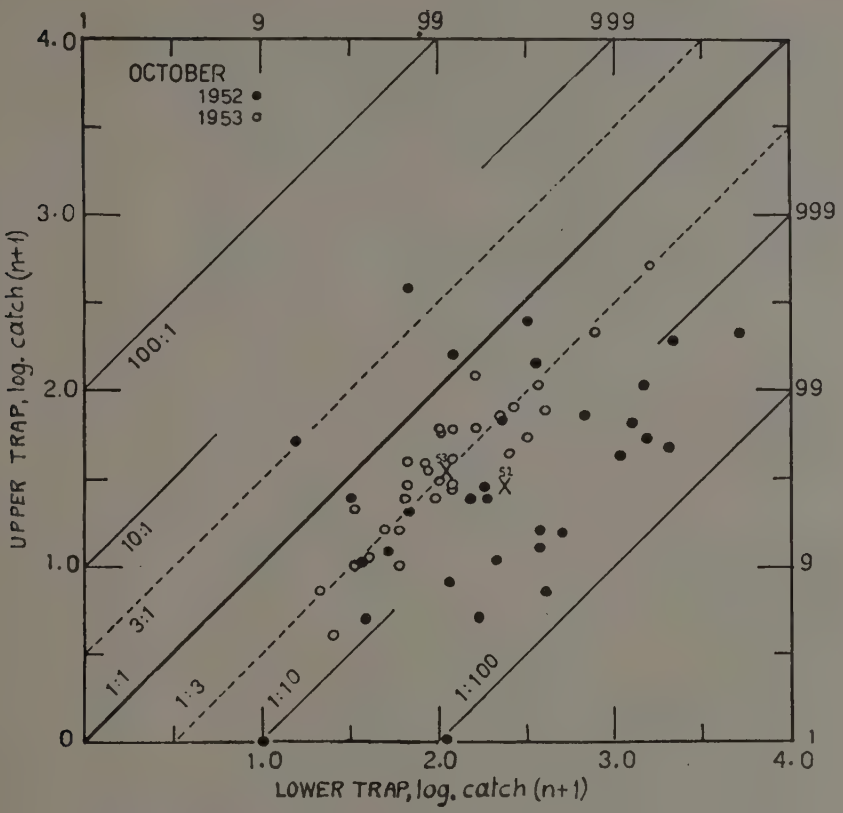

FIG. 5 : Ratios between the log. catch of Diptera per night in the lower and the upper traps in October 1952 and 1953.

in 1952 compared with 0.28 inch in 1953, September 1.87 inches in 1952 compared with 0.54 inch in 1953, and in October 1.15 inch in 1952 and 0.25 inch in 1953.

TABLE I

Physical Factor	May		August		September		October	
	1952	1953	1952	1953	1952	1953	1952	1953
Minimum temperature (1)	46.2	48.7	55.9	55.8	46.8	51.4	43.0	46.3
Maximum temperature	64.2	61.7	69.2	69.2	57.9	63.5	51.9	54.1
Wind 6 feet	3.23	3.77	3.43	3.34	3.67	3.26	3.20	3.06
Wind 30 feet	3.55	4.32	3.51	3.76	3.83	3.51	3.95	2.95
Rainfall	0.71	1.62	2.19	0.28	1.87	0.54	1.15	0.25

(1) Minimum temperature in 1953 was the minimum temperature before midnight.

It was found from a study on the effect of the different weather factors on insect activity (a paper by the junior author under publication) that rain during the night had no significant effect on the activity of Diptera flying at the lower level, but its effect was marked and highly significant in reducing the activity of the Diptera flying at the upper level. So, the difference between the monthly rainfall might

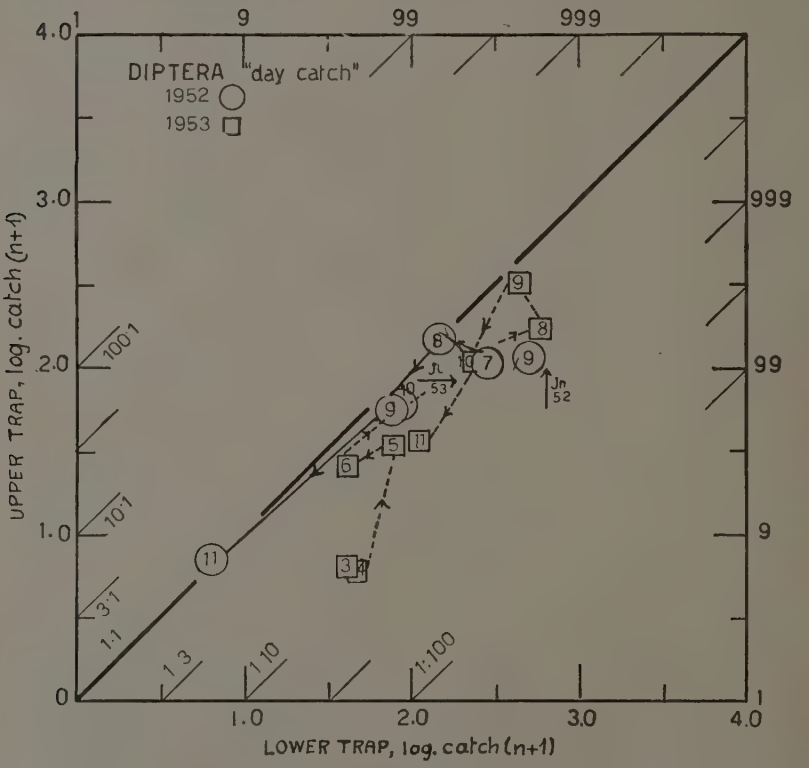

FIG. 6 : Relative distribution of Diptera during the day at the two heights, 5 ft. and 30 ft as indicated by the ratios between the two traps. The figures for June 1952 for the upper trap and July 1953 for the lower trap were not available.

account for the difference in the ratios between the two traps. But if we come to consider May this no longer holds, as unlike the other three months the rainfall was higher in 1953. Other weather factors did not show much difference in the two years.

It can be seen from the Figure that the daily ratios in the two years are larger within the limits of 1:4 and 1:10 in the two years. It may also be of interest to mention that on May 12th 1952 the ratios between the two traps were 1:1. The weather factors during that night were practically the same at the two heights, particularly the wind (4.03 group at 6ft. and 4.04 at 30 ft.). On May 2nd the lower trap caught more than a hundred times as many as the upper, without any obvious reason

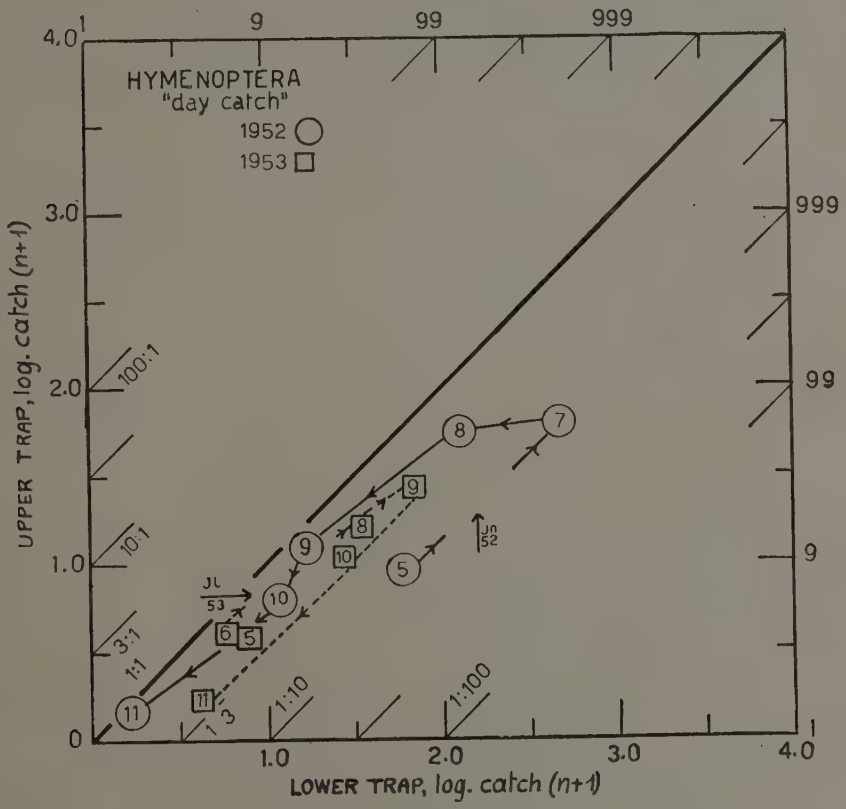

FIG. 7 : Relative distribution of Hymenoptera caught during the day within the heights, 5 ft. and 30 ft.

with weather conditions. The probable reason however may be a sudden emergence of a high number of certain species of insects that evening. On May 22nd 1953, on the other hand, there were almost three times as many in the upper trap as in the lower trap. The wind on this night was higher at the upper than at the lower level

(8.2 m.p.h. and 5.5 m.p.h., respectively) but it is possible that there was a temperature inversion to account for this ratio.

Thus it is likely that the vertical distribution of insects may be modified from one year to another by a change in one of the weather factors but neither of the above causes could be established with certainty unless further trapping and collection of data on special bases must be carried out.

In order to compare night and day activity similar treatment for the different orders captured during the day was carried out.

Considerng first the Diptera, illustrated in Figure 6, we find the sequence of abundance was similar in the two years. However, in 1952 the ratios between the two traps were in most months very close to equality, while in August and November

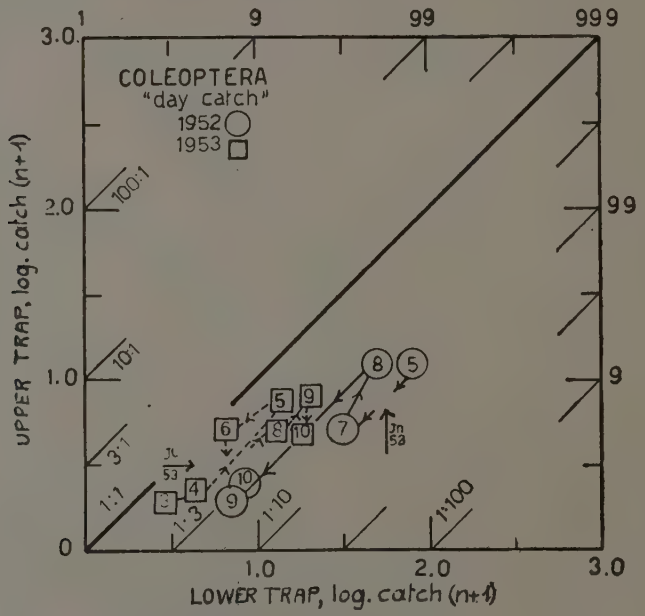

FIG. 8 : Relative distribution of Coleoptera caught during the day at two heights, 5 ft. and 30 ft.

the upper trap actually caught very high number than the lower. On the other hand, in May the ratio was 1:6 and in July 1:3. In 1953 larger differences were obtained in most months, mostly between 1:2 to 1:4. This arrangement is the reverse to what had been obtained at night. The position of the trees close to the traps in 1952 may be responsible for the different ratios obtained for the two years. Possibly many

of the day-flying Diptera are arborial while many of the night flying ones are terrestial but before this can be decided a study in the ecology and flight behaviour of the different species of Diptera is required.

In the orders Hymenoptera, Aphididae and Thysanoptera (Figs. 7-9) the ratios between the two traps tended to be the same. For Hymenoptera, the ratios were of the order 1:2 to 1:3, except May and probably June 1952 which gave larger

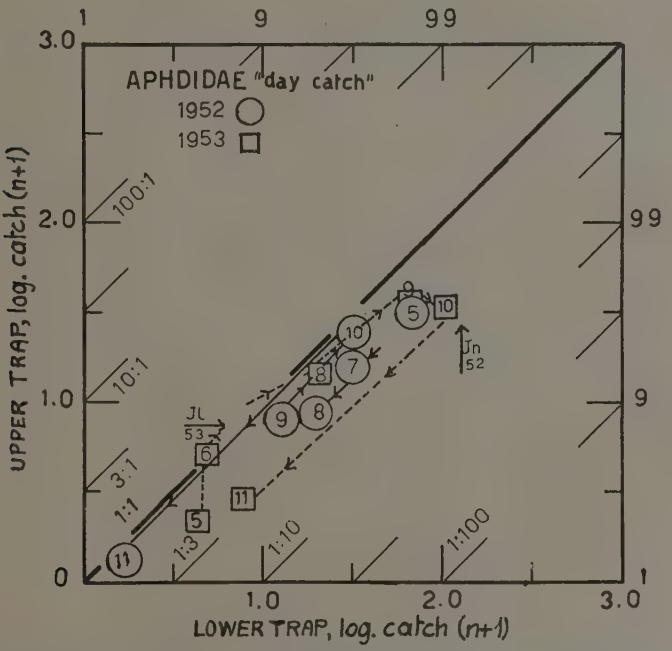

FIG. 9 : Relative distribution of Aphididae caught during the day at the two heights, 5 and 30 feet.

differences (1:6). Aphididae also gave a ratio of 1:2 between the upper and lower trap, with the exception of June 1953 the ratio was almost 1:1 and November 1953 it was 1:3.

Thysanoptera (Fig. 9) too, had a ratio of 1:2 in most of the months except in May 1952 and August 1953 when the ratios were smaller, and in June 1953 the numbers caught in the upper trap were almost 1.5 times the numbers caught in the lower trap.

Coleoptera (Fig. 10), on the other hand, did not give consistent ratios in the two years. They were high in 1952, from 1:9 to 1:3, and low in 1953, from 1:2 to 1:3. It is difficult with our present information to suggest any definite explanation of this.

From the above, it can also be seen that at day and night the ratios normally obtained for the different orders, if not modified by the interference of any cause,

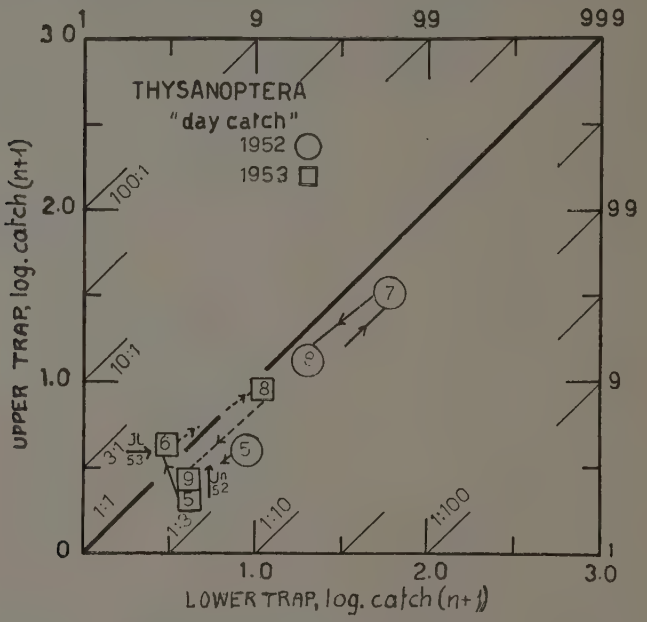

FIG. 10 : Relative distribution of Thysanoptera caught during the day at the two heights, 5 ft. and 30 ft.

were of the order 1:3 which may probably indicate that the density of the population 30 ft. was about one third the population at 5 ft., but still further collection of data is needed before reaching any definite conclusion.

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BOOK REVIEW

TUXEN, S.L. : Taxonomist's Glossary of Genitalia in Insects (E. Munksgaard, Copenhagen, 1956).

This extremely useful work begins with a list of the abbreviations to the figures, and is else divided into two parts. In Part I well illustrated descriptions of the genitalia of all Orders of Insects are given, each dealt with by a specialist of the Order concerned. Part II, entitled "Glossary", is a fairly complete list of the terms and their synonyms used up to the present — in seven languages — in the taxonomic and morphological literature. That the glossary occupies 108 pages shows the great number of synonyms resulting from the fact that so many specialists had their own terminology. The "Glossary" is an important contribution to a simplification of the terminology of the genitalia with regard to future works on this subject. It fills, in any case, an important gap of the entomological literature, and should be present in every entomological library.

BULLETIN

DE LA

SOCIÉTÉ ENTOMOLOGIQUE D'ÉGYPTE

TABLES DES MATIÈRES

DU

QUARANTE-ET-UNIÈME VOLUME

1957

INDEX ALPHABÉTIQUE PAR NOMS D'AUTEURS

PAGES

ABOUL-NASR (Ahmed) : Toxicity of carbon tetrachloride-carbon dioxide mixtures to *Drosophila virilis* Sturt. measured by the rate of wing-beat [Diptera : Drosophilidae] (with 6 Tables) 179

ABOUL-NASR (Ahmed) : Further studies upon the effect of Carbon tetrachloride upon *Drosophila virilis* Sturt. [Diptera : Drosophilidae] (with 9 Tables) 189

ABUL-NASR (Salah) and AWADALLA (Ahmed M.) : External morphology and biology of the bean pod-borer, *Etiella zinckenella* Treit. [Lepidoptera : Pyralidae] (with 15 Text-Figures and 9 Tables) 591

ABUL-NASR (Salah) and EL-NAHAL (A.K.M.) : Field test with some new synthetic insecticides for the control of *Thrips tabaci* on cotton seedlings [Thysanoptera : Thripidae] (with 3 Text-Figures and 3 Tables) .. 577

AHMED (Mostafa Kamal) : Life-history and feeding habits of *Paederus alfierii* Koch [Coleoptera : Staphylinidae] (with 25 Text-Figures and 3 Tables) 129

ALFIERI (A.) : Le genre *Hyperaspis* en Egypte [Coleoptera : Coccinellidae] .. 121

ALFIERI (A.) : Additions à la faune coléptérologique de l'Egypte et du Sinaï (avec 1 Figure) 123

AWADALLA (Ahmed M.) : *see* ABUL-NASR (Salah) and AWADALLA (Ahmed M.) 591

DARWISH (Raafat O.) : *see* GAD (Amin M.) and DARWISH (Raafat O.) .. 535

EBNER (Dr. R.) : Über einige seltene Orthopteren aus Ägypten (2. Teil) .. 117

EL-BOROLLOSY (F.M.) : *see* EL-NAHAL (A.K.M.) and EL-BOROLLOSY (F.M.) 555

EL-KIFL (Dr. Ahmad Hassanain) : The soil Arthropod fauna in a farm at Giza, Egypt (with 18 Text-Figures and 5 Tables) 231

EL-KIFL (Dr. Ahmad Hassanain) : Comparison between a wet and a dry method for extraction of soil Arthropod fauna 525

EL-NAHAL (A.K.M.) : Toxicity of Carbonbi sulphide to *Sitophi lusgranaria* L., *Sitophilus oryzae* L., *Tribolium confusum* Duv., and *Rhizopertha dominica* Fab., under reduced pressure [Coleoptera : Curculionidae, Tenebrionidae, and Bostrychidae] (with 4 Text-Figures and 2 Tables) 457

PAGES

EL-NAHAL (A.K.M.) : *see* ABUL-NASR (Salah) and EL-NAHAL (A.K.M.) 577

EL-NAHAL (A.K.M.) and EL-BOROLLOSY (F.M.) : The relative toxicity of Carbon disulphide to the different larval instars and pupae of *Corcyra cephalonica* Stain. and *Ephestia kuehniella* Zeller [Lepidoptera: Pyralidae] (with 15 Text-Figures and 3 Tables) 555

EL-ZIADY (Samira) : A probable effect of the moonlight on the vertical distribution of Diptera (with 4 Text-Figures and 4 Tables).. 655

EL-ZIADY (Samira) : *see* WILLIAMS (C.B.) and EL-ZIADY (Samira) 663

EZZAT (Y.M.) : Biological studies on the Olive scale, *Parlatoria oleae* (Colvée) [Hemiptera-Homoptera : Coccoidea-Diaspididae] (with 5 Graphs and 6 Text-Figures) 351

EZZAT (Y.M.) : Egg-laying and hatching habits of *Magicicada septemdecim* (Linné) [Hemiptera-Homoptera : Cicadidae] (with 3 Text-Figures, 1 Graph, and 2 Tables) 365

EZZAT (Y.M.) and HIGLAND (H.A.) : The effect of certain insecticides on oxygen consumption of a mealybug [Hemiptera-Homoptera : Coccoidea-Pseudococcidae] (with 3 Graphs) 473

EZZAT (Y.M.) : *see* HOSNY (M.) and EZZAT (Y.M.) 331

FLASCHENTRAEGER (Prof. Dr. ing. et med. B.) : *see* JARCZYK (H. J. and M.) and FLASCHENTRAEGER (Prof. Dr. ing. et med. B.) 621

GAD (Amin M.) and DARWISH (Raafat O.): Mosquitoes collected in Southern Sinai [Diptera] (with 3 Text-Figures) 535

HABIB (A.) : The Asterolecaniinae of Egypt [Hemiptera-Homoptera : Coccoidae-Coccidae] (with 4 Text-Figures) 371

HABIB (A.) : The morphology and biometry of the *Eulecanium corni*-group, and its relation to host-plants [Hemiptera-Homoptera: Coccoidea] (with 15 Text-Figures and 8 Tables) 381

HABIB (Dr. A.) and KHALIFA (Dr. A.) : Population studies on the Black Scale *Chrysomphalus ficus* Ashmead, I [Hemiptera-Homoptera : Coccoidea] (with 14 Text-Figures and 9 Tables) 627

HASSAN (Mahrus Saleh) : Studies on the morphology and biology of *Aphis maidis* Fitch., in Egypt [Hemiptera-Homoptera : Aphididae] (with 26 Text-Figures) 199

HASSAN (Mahrus Saleh) : Studies on the damage and control of *Aphis maidis* Fitch., in Egypt [Hemiptera-Homoptera] (with 22 Text-Figures) 213

HIGLAND (H.A.) : *see* EZZAT (Y.M.) and HIGLAND (H.A.) 473

HOSNY (M.) and EZZAT (Y.M.) : Further additions to the Coccoidea of Egypt [Hemiptera-Homoptera] 331

PAGES

JARCZYK (H.J. and M.) and FLASCHENTRAEGER (Prof. Dr. ing. et med. B.) : Contribution to the biology and biochemistry of the cotton leaf-worm, *Prodenia litura* F., I (with 4 Text-Figures) 621

KHALAF (Kamel T.) : Heleids from Iraq, with description of new species [Diptera : Heleidae (Ceratopogoninae)] (with 11 Text-Figures) 335

KHALIFA (A.) : The development of eggs of some Egyptian species of grasshoppers, with a special reference to the incidence of diapause in the eggs of *Euprepocnemis plorans* Charp. [Orthoptera : Acridiidae] (with 7 Text-Figures and 8 Tables) 299

KHALIFA (Dr. A.) : *see* HABIB (Dr. A.) and KHALIFA (Dr. A.) 627

MAHER ALI (A.) : The food plant and the biology of *Leptoxyda longistylus* (Wied.) in Egypt [Diptera : Trypanaeidae] 485

MAHER ALI (A.) : A study of the nervous system and associated structures in the head of *Bibio marci* (L.) [Diptera : Bibionidae] (with 111 Text-Figures) 489

MAHER ALI (A.) : On the bionomics of *Dacus ciliatus* Loew [Diptera : Trypanaeidae] (with 6 Text-Figures) 527

MAHER ALI (A.) : On the bionomics and control of the Bean-fly, *Agromyza phaseoli* Coq. [Diptera : Agromyzidae] (with 2 Tables) 551

NAKHLA (Naguib B.) : The life-history, habits, and control of the Bersim grasshopper, *Euprepocnemis plorans* Charp., in Egypt [Orthoptera: Acridiidae] (with 9 Text-Figures) 411

PRIESNER (Prof. Dr. H.) : A review of the *Anthophora*-species of Egypt [Hymenoptera : Apidae] 1

SHALABY (A.M.) : On the mouth parts of the larval instars of *Aedes aegypti* (L.) [Diptera : Culicidae] (with 38 Text-Figures) 145

SHALABY (A.M.) : On the mouth parts of the larval instars of *Culex quinquefasciatus* (Say) [Diptera : Culicidae] (with 38 Text-Figures) 269

SHALABY (A.M.) : The mouth parts of the larval instars of *Psorophora ciliata* (Fabricius) [Diptera : Culicidae] (with 39 Text-Figures) .. 429

SHALABY (A.M.) and SHATOURY (H.H.) : The development of a larval lethal mutant in *Culex molestus* Forsk. [Diptera: Culicidae] (with 4 Text-Figures) 477

SHATOURY (H.H.) : *see* SHALABY (A.M.) and SHATOURY (H.H.) 477

SHAZLI (Dr. Ahmed): Direct observation method for measuring the spiracular activity of insects (with 1 Text-Figure) 467

SHAZLI (Dr. Ahmed) : Methods of measuring the spiracular activity of insects (with 2 Text-Figures) 539

WILLIAMS (C.B.) and EL-ZIADY (Samira) : On the relative distribution of insects at 5 and 30 feet (with 10 Text-Figures and 1 Table) 663

LISTE DES ESPÈCES ET VARIÉTÉS NOUVELLES DÉCRITES DANS CE VOLUME

(Les noms en italiques désignent les descriptions)

Diptera

PAGES

Culicoides *iraqensis* KHALAF 343
Culicoides *longipennis* KHALAF 348
Culicoides *micromaculithorax* KHALAF 340
Culicoides *mosulensis* KHALAF 339
Culicoides *pallidus* KHALAF 338
Culicoides *shaklawensis* KHALAF 345
Culicoides similis *baghdadensis* KHALAF 341

Hymenoptera

Anthophora *arabica* PRIESNER 16, 44
Anthophora albigena *afra* PRIESNER 14, 21, 98
Anthophora *alfkenella* PRIESNER 10, 21, 22, 76
Anthophora atricilla *aegyptorum* PRIESNER 7, 18, 27, 30
Anthophora *candidella* PRIESNER 24, 107
Anthophora concinna *hegasica* PRIESNER 9, 24, 75
Anthophora *deceptrix* PRIESNER 15, 23, 105
Anthophora *desertorum* PRIESNER 8, 28, 45
Anthophora *elbana* PRIESNER 10, 64
Anthophora *extricata* PRIESNER 17, 28, 55
Anthophora *extricata clavatipes* PRIESNER 11, 17, 56
Anthophora *facialis* PRIESNER 7, 12, 25, 47
Anthophora *fallaciosa* PRIESNER 10, 70
Anthophora *fayoumensis* PRIESNER 9, 13, 16, 24, 64
Anthophora *flabellata* PRIESNER 9, 18, 50
Anthophora *galalensis* PRIESNER 22, 78
Anthophora *helouanensis* PRIESNER 15, 16, 63
Anthophora *klugi* PRIESNER 14, 19, 90
Anthophora *litorana* PRIESNER 14, 93
Anthophora *maculigera* PRIESNER 10, 85
Anthophora *mellina* PRIESNER 9, 13, 22, 73

PAGES

Anthophora moricei *nigripilis* PRIESNER 17, 27, 57
Anthophora *nivosella* PRIESNER 15, 24, 107
Anthophora *omissa* PRIESNER 19, 95
Anthophora *perlustrata* PRIESNER 10, 71
Anthophora *selecta* PRIESNER 23, 69
Anthophora *shagrensis* PRIESNER 23, 66
Anthophora *spinolana* PRIESNER 8, 18, 26, 49
Anthophora *tarsalis* PRIESNER 10, 23, 109
Anthophora *torensis* PRIESNER 22, 106
Anthophora *tridentella* PRIESNER 13, 23, 71
Anthophora zanoni *borgensis* PRIESNER 11, 28, 58

PUBLICATIONS DE LA SOCIÉTÉ

Bulletins

Vol. I (1908-1909), Vol. II (1910-1911), Vol. III (1912-1913), Vol. IV (1914-1916), Vol. V (1917-1918), Vol. VI (1919-1921), Vol. VII (1922-1923), Vol. VIII (1924), Vol. IX (1925), Vol. X (1926), Vol. XI (1927), Vol. XII (1928), Vol. XIII (1929), Vol. XIV (1930), Vol. XV (1931), Vol. XVI (1932), Vol. XVII (1933) et Vol. XVIII (1934) ..... Epuisés

Vol. XIX (1935) ..... P.Eg. 250
Vol. XX (1936) ..... P.Eg. 250
Vol. XXI (1937) ..... P.Eg. 200
Vol. XXII (1938) ..... P.Eg. 300
Vol. XXIII (1939) ..... P.Eg. 300
Vol. XXIV (1940) ..... P.Eg. 200
Vol. XXV (1941) ..... P.E.g 200
Vol. XXVI (1942) ..... P.Eg. 150
Vol. XXVII (1943) ..... P.Eg. 150
Vol. XXVIII (1944) ..... P.Eg. 250
Vol. XXIX (1945) ..... P.E.g 300
Vol. XXX (1946) ..... P.Eg. 150
Vol. XXXI (1947) ..... P.Eg. 300
Vol. XXXII (1948) ..... P.Eg. 300
Vol. XXXIII (1949) ..... P.Eg. 300
Vol. XXXIV (1950) ..... P.Eg. 250
Vol. XXXV (1951) ..... P.Eg. 250
Vol. XXXVI (1952) ..... P.Eg. 250
Vol. XXXVII (1953) ..... P.Eg. 300
Vol. XXXVIII (1954) ..... P.Eg. 300
Vol. XXXIX (1955) ..... P.Eg. 300
Vol. XL (1956) ..... P.Eg. 300
Vol. XLI (1957) ..... P.Eg. 500

Mémoires

Vol. I (1908-1918), Vol. II (1922-1924) et Vol. III (1928-1929) . Epuisés

Vol. IV
- fascicule 1 (1930) ..... Epuisé
- fascicule 2 (1934) ..... P.Eg. 300
- fascicule 3 (1937) ..... P.Eg. 300

العدد الحادى والاربعون
السنة الخمسون

مجلة الجمعية المصرية لعلم الحشرات

تاسست فى اول اغسطس سنة ١٩٠٧

وضعت تحت رعاية الحكومة المصرية بمرسوم
فى ١٥ مايو سنة ١٩٢٣

مطابع شركة الاعلانات الشرقية
القاهرة - ١٩٥٧